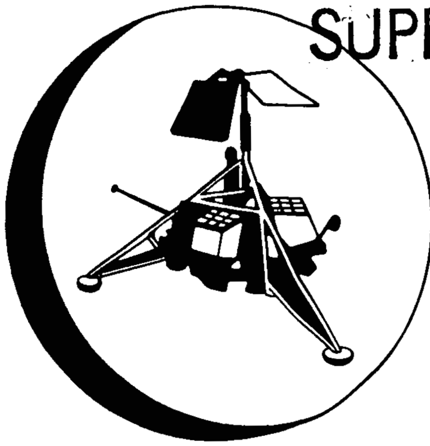


SURVEYOR SPACECRAFT

A-21

FUNCTIONAL DESCRIPTION

VOLUME I

[redacted]

HUGHES

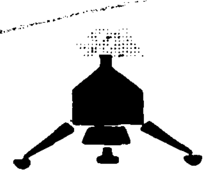
SURVEYOR PROGRAM
SPACE SYSTEMS DIVISION
HUGHES AIRCRAFT COMPANY
EL SEGUNDO, CALIFORNIA

39524

HAC PUB. NO. 70-93401

JPL contract

SURVEYOR SPACECRAFT.



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FUNCTIONAL DESCRIPTION

VOLUME I:
(OF THREE)

NUMBER
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Prepared by R. P. Harvey Date 15 April 1966

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HUGHES

SPACE SYSTEMS DIVISION
HUGHES AIRCRAFT COMPANY
EL SEGUNDO, CALIF.

1 NOV 64
CHANGED 15 APRIL 1966

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SECTION I

INTRODUCTION

GENERAL

This publication, which consists of three volumes, provides a functional description of Surveyor Spacecraft A-21. For purposes of description, the spacecraft system is divided into eight major functions, each of which is further divided into subfunctional areas. This functional division provides ready access to the descriptions of each circuit and mechanism within the spacecraft used to perform a specific function. Three major items are utilized to provide the basic functional description: functional block diagrams, and functional schematic diagrams, and functional theory.

author

~~Contents of Volume I~~

Volume I contains a general description of the major functional areas of the system. The major functional areas consist of the RF DATA LINK, COMMAND DECODING, SIGNAL PROCESSING, FLIGHT CONTROL, TELEVISION CAMERAS, MECHANICAL AND THERMAL SERVICES, VEHICLE ENGINEERING, POWER MANAGEMENT function and the CENTAUR INTERFACE.

Contents of Volume II

Volume II contains functional schematic diagrams of items within the eight major functional areas of the system and functional theory on a level compatible with the diagrams. It also contains commutation data to be used in conjunction with the SIGNAL PROCESSING diagrams.

Contents of Volume III

Volume III contains information on all signals which are telemetered by the system. Each signal is described by a data sheet. Signal data sheets are grouped into ten functional groups. These functional groups are arranged for convenience in this volume and do not correspond to the functional arrangement in the other volumes.

Contents of Supplement

The Supplement contains functional schematic diagrams and functional theory for only those control items which differ on succeeding A-21 spacecraft.

SPACECRAFT MISSION

The A-21 spacecraft carries a payload consisting of engineering instrumentation and a survey television camera. The purpose of this spacecraft is to provide information for a scientifically-instrumented landing.

The A21 spacecraft operates through a complete engineering mission. The mission consists of recording the data at each stage which will verify the successful operation of the vehicle; and the determination of alternate procedures suitable for correcting malfunctions or minimizing the operational effect of such malfunctions in later spacecraft.

Functional Diagram Format

Coded figure designators are assigned to each diagram. These designators indicate the interrelations of individual diagrams within the composite system. For example:

Section No. - Major Functional Grouping (Signal Processing)

5 th Subfunctional of Major Functional (Current Measurement)

Figure 5.1.5.4

1 st Major Functional of Grouping (Commutators)

4 th Diagram of Subfunctional

Appropriate figure references on individual diagrams provide for continuity of data flow from diagram to diagram within and between major functional groupings.

Functional Theory

The functional theory complements the functional diagrams with respect to division of the spacecraft system and the detail included. Generally, the theory is divided into sections, each section corresponding to one diagram. However, a theory section may reference more than one diagram or part of one diagram. (See the titles of theory sections listed in the table of contents.) The following rules of format are used in the theory.

1. Signal Nomenclature - All inter-unit signal nomenclature: Initial capitalization, enclosed in quotation marks.

2. Circuit Nomenclature - All circuit nomenclature used on Functional Diagrams, such as the name of a circuit block or circuit area composed of several circuit blocks: All capitalized.

3. Control Item Nomenclature - All control item nomenclature used in the text: Initial capitalization, underlined.

4. Unit Nomenclature - All nomenclature of units subordinate to control items: Initial capitalization only.

Each section of theory is divided into three parts, as follows:

(1) GENERAL--This part states what elements constitute the circuits and mechanisms of the subfunction being described (i.e., solid state, relays, etc.), what control items are utilized, the purposes of the subfunction, and a basic outline of the operations performed by the elements and their relationship to the overall system.

(2) OPERATIONAL REQUIREMENTS--This part states what power or conditions are necessary for operation of the subfunction.

(3) OPERATIONAL THEORY--This part presents the actual theory of operation, and is keyed to and gives the same detail as the diagrams. The description generally follows the signal flow of the diagrams, being divided into sections corresponding to typical input command or signal sequence, modes of operation, or individual autonomous elements.

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SECTION II

SURVEYOR SYSTEM

Prepared by E. J. Bennett date 2 June '64
Approved by R.C. Pietropaolo date 2 June '64

This section contains a description of the major functional areas of the Surveyor Spacecraft system, a chronological mission sequence, and a functional block diagram of the system. Each major functional area of the system is described in the text and is separately enclosed on the functional block diagram. Each block on the diagram is identified by an index number corresponding to the figure or figures in the succeeding sections of this publication. Each of the major functional areas occupies a separate succeeding section of this document.

Table 2-1 indicates the Control Item Nomenclature and current basic part numbers. The current status of the Functional Description as related to the Engineering Change Analyses (ECA's) is shown in Table 2-1 of Volume II. The units are identified by the Unit Reference Desginator (URD) number which appears in the lower right corner of the various blocks on the diagrams 3.0 thru 11.0.

TABLE 2-1

CONTROL ITEMS

UNIT REFERENCE DESIGNATOR	CONTROL ITEM NOMENCLATURE	CONTROL ITEM PART NO.
1	FLIGHT CONTROL SENSOR GROUP	235000
2	SECONDARY SUN SENSOR	235450
3, 4, 5	ATTITUDE JET NO. 1, 2, 3	235700
6	ATTITUDE JET GAS SUPPLY	235600
7	ROLL ACTUATOR	235900

TABLE 2-1. (Cont)

UNIT REFERENCE DESIGNATOR	CONTROL ITEM NOMENCLATURE	CONTROL ITEM PART NO.
33	PLANAR ARRAY ANTENNA	232300
36	ALTITUDE MARKING RADAR	283827
37	RADVS SIGNAL DATA CONVERTER	232908
38	RADVS KLYSTRON POWER SUPPLY MODULATOR	232909
39	RADVS ALTIMETER/VELOCITY SENSOR ANTENNA	232910
40	RADVS VELOCITY SENSOR ANTENNA	232911
41	RADVS WAVEGUIDE ASSEMBLY	232912
42	BOOST REGULATOR	274200
43	RADIO FREQUENCY TRANSFER SWITCH	283984
44	CENTRAL COMMAND DECODER	232000
45	CENTRAL SIGNAL PROCESSOR	232200
49, 50	TRANSMITTER A & B	263220
51, 52	COMMAND RECEIVER AND TRANSPONDER A & B	231900
53	ENGINEERING SIGNAL PROCESSOR	233350
57	APPROACH TELEVISION CAMERA	284302
73	ENGINEERING MECHANISM AUXILIARIES	263500
78	SOLAR PANEL	237760
79	MAIN BATTERY	237900

TABLE 2-1. (Cont)

UNIT REFERENCE DESIGNATOR	CONTROL ITEM NOMENCLATURE	CONTROL ITEM PART NO.
81	ANTENNA AND SOLAR PANEL POSITIONER	287550
82	ANTENNA MECHANISM-OMNI DIRECTIONAL A	287300
112	FUEL TANK NO. 1	287001
113	FUEL TANK NO. 2	287001
114	FUEL TANK NO. 3	287000
115	OXIDIZER TANK NO. 1	287002
116	OXIDIZER TANK NO. 2	287004
117	OXIDIZER TANK NO. 3	287003
118, 119, 120	THRUST CHAMBER ASSY NO. 1, 2, 3	285063
129	THERMAL TRAY ASSY-COMPARTMENT B	276935
130	THERMAL TRAY ASSY-COMPARTMENT A	264334
131	WIRING HARNESS NO. 1 BASIC BUS	286473
133	WIRING HARNESS-COMPARTMENT A	276951
134	WIRING HARNESS-COMPARTMENT B	264094
140, 141, 142	RETRO ROCKET RELEASE MECHANISM LEG NO. 1, 2, 3	230069
145	RADIO FREQUENCY SINGLE POLE DOUBLE THROW SWITCH	283983
148, 149, 150	SEPARATION SENSING AND ARMING DEVICE LEG NO. 1, 2, 3	293000

TABLE 2-1. (Cont)

UNIT REFERENCE DESIGNATOR	CONTROL ITEM NOMENCLATURE	CONTROL ITEM PART NO.
152, 153, 154	CARTRIDGE ACTUATED PIN PULLER LEG NO. 1, 2, 3	287302
167, 168, 169, 170	ACCELEROMETER NO. 1, 2, 3, 4 LEG NO. 1, 2, 3, FCSG	239002
174	ACCELEROMETER AMPLIFIER ASSY	239011
176	VERNIER PROPULSION SYSTEM AND SPACEFRAME ASSY	264334
180	SURVEY TELEVISION CAMERA	284312
183	TELEVISION AUXILIARY	232106
185	RETRO ROCKET ENGINE	238613
186	LANDING GEAR NO. 1	261278
187	LANDING GEAR NO. 2	261279
188	LANDING GEAR NO. 3	261280
198, 199	THERMAL CONTROL AND HEATER ASSEMBLY-COMPARTMENT A & B	232210
201	ANTENNA MECHANISM-OMNI DIRECTIONAL B	273880
236	ANTENNA AND SOLAR PANEL POSITIONER WIRING HARNESS	286417
237	RETRO ROCKET MOTOR WIRING HARNESS	286390
255	SIGNAL PROCESSING AUXILIARY	232540
260, 261, 262	SHOCK ABSORBER-LEG NO. 1, 2, 3	X230575

TABLE 2-1. (Cont)

UNIT REFERENCE DESIGNATOR	CONTROL ITEM NOMENCLATURE	CONTROL ITEM PART NO.
265	WIRING HARNESS NO. 2-BASIC BUS	286398
268	RF CABLE ASSEMBLY, XMTR A	261711
269	RF CABLE ASSEMBLY, RF XFR SW	261712
270	RF CABLE ASSEMBLY, XMTR A	261713
271	RF CABLE ASSEMBLY, PLANAR ARRAY	261714
273	RF CABLE ASSEMBLY, OMNI-A	261719
274	RF CABLE ASSEMBLY, OMNI-A	261720
287	LOW DATA RATE AUXILIARY	264875
288	AUXILIARY BATTERY	237921
289	AUXILIARY BATTERY CONTROL UNIT	273000
290	AUXILIARY ENG SIGNAL PROCESSOR	264900
291	AUXILIARY BATTERY COMPARTMENT	263730
296	SPACEFRAME SUBASSEMBLY	264178
299	TV CAMERA WIRING HARNESS	276979
310	THERMAL SHELL ASSEMBLY-COMPARTMENT A	263997
311	THERMAL SHELL ASSEMBLY-COMPARTMENT B	230134
319, 320, 321, 322	ACCELEROMETER NOS. 5, 6, 7, 8	239002
327	STRAIN GAGE AMPLIFIER ASSEMBLY-LEG NO. 3	238930

TABLE 2-1. (Cont)

UNIT REFERENCE DESIGNATOR	CONTROL ITEM NOMENCLATURE	CONTROL ITEM PART NO.
328-335	COAXIAL CABLE-ACCELEROMETERS	239013
337	RF CABLE ASSEMBLY, PLANAR ARRAY	261719
338	RF CABLE ASSEMBLY, OMNI-B	261720
341	RF CABLE ASSEMBLY, OMNI-B	261719
342	RF CABLE ASSEMBLY, OMNI-B	261721
344	RF CABLE ASSEMBLY, XFR SW	261712
345, 346	RF CABLE ASSEMBLY, XMTR A, B	276266
351	RF CABLE ASSEMBLY, XMTR B	261711
352	AUXILIARY BATTERY WIRING HARNESS	264100
353, 354	CARTRIDGE ACTUATED PIN PULLER-MECHANICAL OMNI DIRECTIONAL ANTENNA A, B	287553
355	BATTERY CHARGE REGULATOR	274100
357, 358	LOW PASS FILTERS A & B	233466
359	HELIUM TANK AND VALVE ASSEMBLY	262789
360	THERMAL RESISTOR, CALIBRATED TEMPERATURE SENSING CRUSHABLE BLOCK	988653
361	CARTRIDGE ACTUATED PIN PULLER-ROLL ACTUATOR	287548
362	RF CABLE ASSEMBLY, PLANAR ARRAY	276828
363	MAIN POWER SWITCH	254112

TABLE 2-1. (Cont)

UNIT REFERENCE DESIGNATOR	CONTROL ITEM NOMENCLATURE	CONTROL ITEM PART NO.
364	TRANSDUCER	262609
365	THERMOSTAT HTR & TEMP SENSING ASSEMBLY, LEG 1	238673
366	THERMOSTAT HTR & TEMP SENSING ASSEMBLY, LEG 2	262556
367	THERMOSTAT HTR & TEMP SENSING ASSEMBLY, LEG 3	262557
397	BOOST REGULATOR FILTER ASSEMBLY	284144
398	TRANSMITTER FILTER ASSEMBLY	284414
399	BOOST REGULATOR UNREGULATED BUS FILTER	290060
400, 401	RECEIVER BUFFER A, B	290780
402	BOOST REGULATOR UNREGULATED BUS CHOKE	290390
403	BATTERY CELL VOLTAGE WIRE HARNESS	3025155
NA	OMNI DIRECTIONAL ANTENNA A, B	232400

2.1 SPACECRAFT SUBSYSTEMS. (Fig. 2.1)

2.2 GENERAL.

The Surveyor Spacecraft is composed of eight basic functional areas, as follows:

a. RF DATA LINK FUNCTION

b. COMMAND DECODING FUNCTION

c. SIGNAL PROCESSING FUNCTION

d. FLIGHT CONTROL FUNCTION

e. TELEVISION CAMERAS

f. MECHANICAL AND THERMAL SERVICES

g. VEHICLE ENGINEERING INSTRUMENTATION

h. POWER MANAGEMENT

These functional areas include blocks representing all of the electrical and mechanical equipment essential to the operation of the spacecraft.

2.3 RF DATA LINK FUNCTION

The RF DATA LINK FUNCTION consists of the equipment associated with transmitting and receiving telemetered information in communication and in tracking by transponder operation with the DSIF. All signals to be telemetered to earth are supplied to either TRANSMITTER A or TRANSMITTER B. Each transmitter is capable of providing a high power (10 watt) or low power (0.1 watt) output, which, in either case, can be frequency modulated or phase modulated. TRANSMITTER A is kept in standby condition and TRANSMITTER B performs the transmitting function during normal operation.

The spacecraft is equipped with three antennas, two OMNI antennas and the PLANAR ARRAY. All of the antennas are capable of operating with the transmitters in the high or low power mode. The PLANAR ARRAY is required for efficient transmission of television signals. Switching allows the use of alternate antennas with the transmitters.

RECEIVER/TRANSPONDER A and RECEIVER/TRANSPONDER B are identical. Each is directly connected to one of the OMNI antennas. The receiver/transponders also provide a phase-coherent system for Doppler tracking from the DSIF.

2.4 Command Decoding Function.

The COMMAND DECODING FUNCTION receives the commands detected by the RF Data Link Function. The commands, "Receiver A Output" and "Receiver B Output", are used by the two Central Command Decoders to generate sync and timing signals.

The commands are also supplied to the RECEIVER/DECODER SELECTOR which selects the combinations of receivers and Central Command Decoders.

If either receiver fails to supply output signals, the RECEIVER/DECODER SELECTOR changes the receiver-decoder combination. Altogether, four combinations are possible. Selection can be made by interrupting the flow of messages to the spacecraft.

The SUBSYSTEM DECODERS receive the direct command outputs of the Central Command Decoders; they supply specific commands to the other functions of the system.

2.5 Signal Processing.

The SIGNAL PROCESSING FUNCTION gathers data produced by the other areas of the system and prepares the data for transmission by the RF DATA LINK to the DSIF. The information is that necessary to monitor all of the spacecraft functions; the majority of the information has been preprocessed to be within the range of 0 to 5 vdc.

The COMMUTATION section divides the data signals into several groups. The signals in each group, called a commutator mode, are sent on a time-shared basis, each signal having one or more places in a sequence. The particular mode to be telemetered is commanded by the DSIF. The sequence of signals comprising the mode is sent to the ANALOG/DIGITAL CONVERSION equipment. The analog signals are converted into 10-digit binary numbers. The signals are combined with sync words, have a parity digit added, and are sent to a group of five SUBCARRIER OSCILLATORS.

The output frequencies of the SUBCARRIER OSCILLATORS are modulated by the digital output of the ANALOG/DIGITAL CONVERSION circuitry. Five oscillator output frequencies are used, each being used for a different data rate. The output signals are combined by the SUMMING AMPLIFIERS and sent to TRANSMITTER A and TRANSMITTER B of the RF DATA LINK FUNCTION.

2.6 Flight Control Function.

The FLIGHT CONTROL FUNCTION provides all spacecraft attitude control during transit and all velocity control during the thrust phases of transit.

The INERTIAL & CELESTIAL SENSORS provide a fixed reference during most of transit by taking a celestial fix or by holding a given inertial reference. When the vernier descent phase is in progress, the RADVS provides signals for orientation of the spacecraft with respect to the moon's surface.

The RADVS and INERTIAL & CELESTIAL SENSORS supply their attitude and thrust control signals to the ANALOG ELECTRONICS. The ANALOG ELECTRONICS apply the appropriate signals to the GAS JETS for attitude control and to the VERNIER PROPULSION for the control of thrust level and thrust moments.

The RETRO ROCKET ignites in response to a firing signal from the MECHANICAL and THERMAL SERVICES FUNCTION. The ALTITUDE MARKING RADAR produces a trigger signal when the spacecraft altitude is 60 miles above the lunar surface. The trigger causes the flight control DIGITAL PROGRAMMING to produce a control signal for the MECHANICAL and THERMAL SERVICES to fire and RETRO ROCKET squib.

The DIGITAL PROGRAMMING section produces digital output signals for control of mode selection and sequencing within the FLIGHT CONTROL FUNCTION. The section performs these operations in response to commands received from the ground (via the COMMAND DECODING FUNCTION) and from the other sections of the FLIGHT CONTROL FUNCTION that indicate operations performed.

The RADVS section measures the slant range to the lunar surface and the velocity along the three mutually perpendicular spacecraft axes.

2.7 Television Cameras.

The TELEVISION FUNCTION contains TV3 (SURVEY CAMERA) and TV4 (APPROACH CAMERA). The purpose of the SURVEY CAMERA is to transmit pictures of selected portions of the lunar surface upon command from Earth. The APPROACH CAMERA will supply pictures of the lunar surface from 1000 miles above the lunar surface to a point 80 ± 20 miles above the lunar surface. The SURVEY CAMERA only is equipped with mirrors that enable 360-degree azimuth and 60-degree elevation viewing, colored filters, an adjustable focus, focal length, and iris. Both the survey and approach cameras are self contained in that they require only primary electrical power and command signals for operation. Power and command signals for the approach and survey cameras are supplied by SUBSYSTEM DECODERS NO. 01 (SSD01) and 11 (SSD11).

The principal signal output from TV3 and 4 is a composite single frame video, "TV3 Video or TV4 Video."

The single frame video outputs from the TV camera(s) when on are supplied to summing amplifiers in the TV Auxiliary and from there to the transmitters for relay to Earth.

2.8 Mechanical and Thermal Services.

The MECHANICAL and THERMAL SERVICES FUNCTION performs various actuation and temperature control operations. The SQUIB FIRING POWER SUPPLIES and SEPARATION SENSING & ARMING SWITCH ignite the squib which fires the RETRO ROCKET of the FLIGHT CONTROL FUNCTION. The power supplies are controlled by a trigger signal from DIGITAL PROGRAMMING.

Several squibs perform one-shot release or dumping operations. The LEG POSITION POTENTIOMETERS confirm that the landing legs have been fully extended. Several motors within the MECHANICAL section control the positioning of the Solar Panel and the Planar Array on the mast.

The THERMAL section provides heating for temperature sensitive components. The TV3 HTR BLANKET and TV4 HTR BLANKET are turned off during camera operation to prevent distortion of the picture.

2.9 Vehicle Engineering Instrumentation.

The VEHICLE ENGINEERING INSTRUMENTATION consists entirely of TEMPERATURE SENSORS, ACCELEROMETERS, and STRAIN GAGES. Spacecraft performance is measured by these sensors and sent to SIGNAL PROCESSING for telemetry. Before separation from the boost vehicle during the launch phase, the ACCELEROMETERS outputs are telemetered via the Centaur Interface.

The TEMPERATURE SENSORS consist of 74 resistive type thermal sensors. They are distributed throughout the spacecraft as listed on the diagram.

Three STRAIN GAGES are mounted on the Vernier Engine Thrust Chambers and one on the Retro Rocket. Three others are mounted on the hydraulic shock absorbers for each of the landing legs; they measure the impact at touchdown.

2.10 Power Management.

The POWER MANAGEMENT FUNCTION supplies all power to the spacecraft during transit. The POWER CONVERSION SWITCHING & STORAGE section converts solar energy into electrical power and stores it in batteries for use during peak periods. The BOOST REGULATION section converts and regulates the Solar Panel output and the battery current into the voltages necessary for operation of the other functions of the spacecraft. Unregulated 22 v power is supplied directly to the Altitude Marking Radar and other areas which perform their own regulation.

2.11 Centaur Interface.

The Centaur Interface provides the interconnection between the spacecraft and the Centaur boost vehicle during launch, and telemetry of information is made through the Centaur. Ground commands, such as those to extend the landing legs and the Omni Antenna are made prior to separation; these are transmitted to the Centaur. The commands are then supplied to the spacecraft via the Centaur Interface.

2.12 Mission Sequence.

The basic mission of the Sruveyor Spacecraft requires nominally 1 hr 30 min of prelaunch time and approximately 62 hr of transit time to complete. During the transit time, the three DSIF stations alternate control over the spacecraft functions as each comes within view. Critical operations such as the midcourse maneuver and the descent phases are timed to coincide with control by the Goldstone DSIF.

Most spacecraft operations are performed in response to radio commands. This allows the spacecraft to make less provision for programming equipment than would otherwise be the case.

2.13 PRELAUNCH. Prelaunch operations for the Surveyor Spacecraft consist of countdown checks performed by the Surveyor Test Equipment Auxiliary (STEA) via data link. After the command link has been established, the STEA measures the spacecraft transmitter power and frequency and the receiver frequency. These quantities are measured until launch time. Malfunctions that are detected will cause launch to be held back until the fault is corrected. This sequence begins about 1 hr 30 min before launch.

At least 1 hr before launch, the spacecraft launch conditions are set. The Engineering Commutator is turned on to Modes 1, 2, and 4 in turn; decommutator sync pulses (COMMUTATION) and certain gyro output signals (INTERTIAL & CELESTIAL SENSORS) are observed. Flight control power is turned on and several flight control operations are observed on Engineering Commutator Mode 1. At this time all flight control electronics that operate during nonpowered flight are turned on.

About 3 seconds before launch, the umbilical is removed from the Centaur boost vehicle and all direct connections are severed.

2.14 LAUNCH TO INJECTION. During the launch phase of the transit, telemetering of data is accomplished via the Centaur. Shock and vibration data are transmitted during this time.

The data is also applied to the spacecraft telemetry system so that the information can be telemetered after separation from the boost vehicle.

At an altitude of about 60 miles, the shroud protecting the spacecraft from the atmosphere is ejected.

2.15 SEPARATION AND DSIF ACQUISITION. To allow the spacecraft to fit into the shroud, the landing legs, Omni Antennas and Solar Panel are stowed in a collapsed position. Signals are supplied by the boost vehicle to extend the legs and antenna into their operating positions.

Also at this time, the spacecraft high power transmitter is turned on. This assures that signal strength will be great enough for initial DSIF acquisition. The outputs of the transmitter TWT's are switched to the Omni Antenna.

At about 12 min 30 sec after launch, separation of the spacecraft from the spent boost vehicle occurs. The Separation Sensing and Arming Devices initiate automatic deployment of the Solar Panel and the mast roll axis to transit positions by the Antenna and Solar Panel Positioner. The Gas Jets on the ends of the landing legs stop the rotation imparted to the spacecraft as a result of separation. The flight control analog electronics provide control signals for the Gas Jets in response to the Inertial Sensors which are operating in a rate mode.

Various flight control signals are monitored through the Auxiliary Commutator for coast phase.

At about 24 min after launch, DSIF acquisition is attempted. To begin with, the DSIF tunes its receiver to the spacecraft transmitter frequency. Then the ground transmitter is tuned, nominally ±15 kc, until its signal appears within the tuning range of the spacecraft receiver as indicated by a shift in the spacecraft transmitter frequency. The spacecraft transmitter is now phase locked to the DSIF transmitter signal and follows the spacecraft receiver frequency. The ground receiver is then slaved to the ground transmitter so that all 4 elements are operating on the same nominal frequency.

The Auxiliary Commutator is turned off and the Engineering Commutator is turned on to Mode 4.

2.16 ATTITUDE REFERENCE ACQUISITION. During this phase the spacecraft is locked onto the sun and the star Canopus. The maneuvers align the solar panel for maximum illumination by the sun, establish a known spacecraft orientation for later maneuvers, and orient the spacecraft for optimum thermal control.

The transmitter high power is turned off for awhile to avoid overheating. Sun acquisition and lockon is initiated by ground command. After sun lockon, star acquisition is initiated by another ground command. Verification that the star locked on to is truly Canopus is made by rolling the spacecraft and making a map of the stars encountered.

During sun acquisition, flight control signals are monitored by Engineering Commutator Mode 1.

During star acquisition, pertinent flight control operations are monitored through Mode 4.

Sun lockon must be accomplished within an hour after launch to prevent heat damage to sensitive components. Star lockon may be delayed until the spacecraft has cleared the Van Allen radiation area where the Canopus Sensor probably will be inoperative.

The flight control cruise mode is commanded on to cause the flight control to revert to an inertial hold if Canopus or sun lockon is lost.

2.17 COAST PHASE. During the coast phase, the Space Flight Operations Facility (SFOF) calculates the orbit of the spacecraft so that the amount of midcourse correction required to make a satisfactory lunar landing may be determined.

2.18 STAR VERIFICATION. Verification is performed to ensure that the Canopus Sensor has locked onto Canopus and not another star which falls within the upper and lower thresholds for lockon. The spacecraft performs a roll maneuver on command from the ground and telemeters back the intensity of the starlight falling on the Canopus Sensor.

Telemetering of spacecraft data is accomplished on Modes 1, 2, and 4 of the Engineering Commutator. The data is transmitted at high power unless the db gain is such that low power is adequate for the bit rate.

2.19 COAST MODE I. During this period of time, the Space Flight Operations Facility makes its final orbit determinations and completes the calculation of the midcourse correction.

An engineering interrogation of the data on Modes 1, 2, and 4 of the Engineering Commutator is performed. As previously, the interrogation is conducted at high power unless low power is sufficient for the 1100 bps data rate.

2.20 MIDCOURSE MANEUVER. At about 14 hr 30 min after launch the ground station performs a high power engineering interrogation on Engineering Commutator Modes 4, 2 and 1 in that order. Mode 1 is left on during succeeding operations.

Commands are sent from the ground station to reorient the spacecraft attitude so that thrust can be applied in the direction required to insure that the trajectory of the spacecraft will land it at a suitable location on the moon. The Vernier Engines are turned on for specified periods of time to accomplish the correction to the velocity vector.

After the velocity correction, the spacecraft is reoriented back to its normal transit position either by commanding a reverse maneuver from the previous one or, if the gyros of the Inertial Reference Unit have exceeded their 10 degree limits, sun and Canopus acquisition is performed again.

Engineering Commutator Mode 2 and 4 are turned on, respectively. The flight control cruise mode is commanded.

2.21 COAST MODE II. At about 17 hr 42 min after launch, the spacecraft goes into the second coast mode. This mode lasts about 47 hr. Canopus verification is accomplished in the same manner as during the attitude reference acquisition phase.

SFOF completes power and thermal computations on the spacecraft and an orbit determination.

A low power interrogation is accomplished by sampling Engineering Commutator Modes 1, 2, and 4. The purpose of this interrogation is to obtain spacecraft temperatures.

SFOF completes computations of the maneuvers required during the retro and vernier descent phases. These calculations involve the maneuver angles, proper time for enabling the Altitude Marking Radar, correct retro ignition delay, and the pointing angle for the high gain Planar Array.

A high power engineering interrogation is performed on Mode 4. The Altitude Marking Radar heater is turned on; this is accomplished about 3 hr before Retro Rocket ignition. The vidicon and electronics temperature controls for the Television Cameras are turned on so that the cameras are available for operation in the event of a nonstandard situation.

2.22 PRE-RETRO MANEUVER. At approximately 64 hr 30 min after launch, the pre-retro maneuver is begun. The last interrogation is made of various transmitter operations and power and temperatures which were measured in other interrogations.

The planar array is commanded to move to its landing position. A combination roll and pitch or yaw maneuver is commanded to align the Vernier Engine thrust vector with the velocity vector of the spacecraft. Another command initiates a roll maneuver to point the Planar Array toward the earth.

The spacecraft is now placed in an inertial hold mode. Television Camera No. 4 is turned on. A sequence is initiated in which 10 pictures are taken and then 5 seconds of data from Mode 2 are transmitted. The last picture will be taken at about 80 miles altitude.

Approximately 5 min before Retro Rocket ignition, the Altitude Marking Radar power is turned on and thrust phase power is turned on. When the spacecraft is 120 ±45 miles, the Altitude Marking Radar is enabled; the exact altitude is determined from the computations performed during coast mode II.

2.23 RETRO DESCENT. At approximately 61 hr 58 min after launch, the retro descent phase is begun. The Altitude Marking Radar triggers at approximately 60 miles; this provides an ignition signal for the Vernier Engines and starts a delay sequence for the Retro Rocket firing. After a delay of about 1 sec to allow the Vernier Engines to stabilize their thrust, the Retro Rocket is ignited. Approximately half a second later, the RADVS begins to operate. The Altitude Marking Radar is blown away by the gas pressure of the retro ignition squib. The spacecraft is in an inertial hold mode controlled by the firing of the Vernier Engines.

An attempt is made to obtain two television pictures during retro descent.

The Retro Rocket produces about 9000 lbs. of thrust for approximately 47 sec. After burnout, a burnout signal is generated by the Flight Control Function. The thrust level of the Vernier Engines is increased and the spent Retro Rocket is ejected approximately 8 seconds later. A single television picture is taken at ejection.

2.24 VERNIER DESCENT. About 10 sec after burnout, the Retro Rocket has separated from the spacecraft by a sufficient amount to allow attitude maneuvers to be performed which are controlled by the RADVS.

If the planar array antenna is still in view of the Earth, television pictures are transmitted every 20 sec. Engineering data is telemetered to earth by means of Mode 3. Touchdown strain gage power is turned on and the data channels are on. At 1000 feet altitude the RADVS shifts the scale factor of its altitude output when it changes to more precise measurements.

At an approach velocity of 10 feet per second, pitch and yaw control reverts from RADVS slaved to inertial hold and a constant velocity of 5 feet per second is maintained.

When the spacecraft has dropped to an altitude of only 13 feet, the RADVS generates a signal which turns off the Vernier Engines; the spacecraft drops the remaining distance to the lunar surface.

Flight control power is shut off and the spacecraft is prepared for lunar operations by turning off equipment which is of no further use. Engineering Commutator Mode 1, the high power transmitter, and vidicon temperature control for Television Camera No. 3 is on for the start of the lunar operation.

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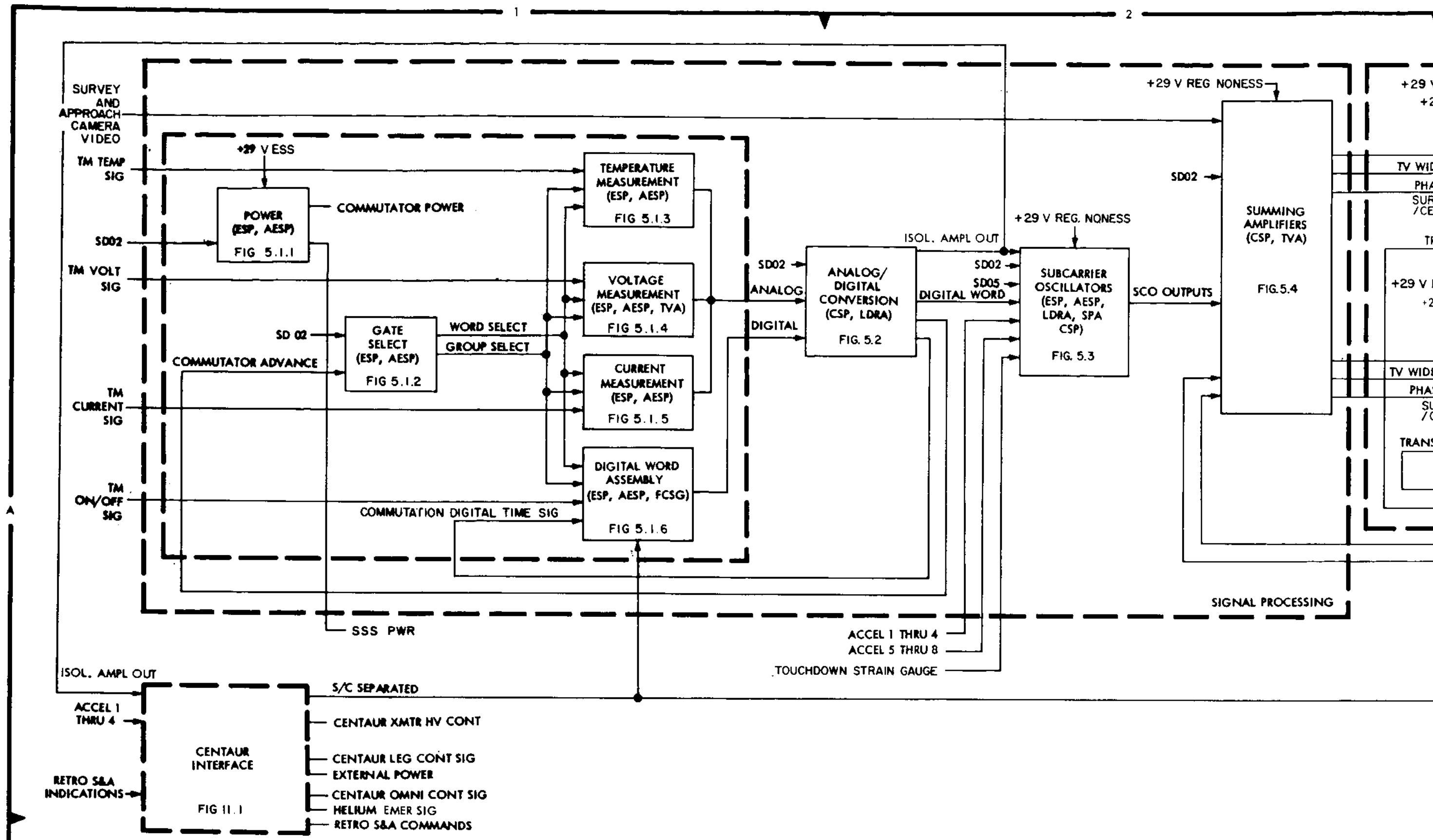
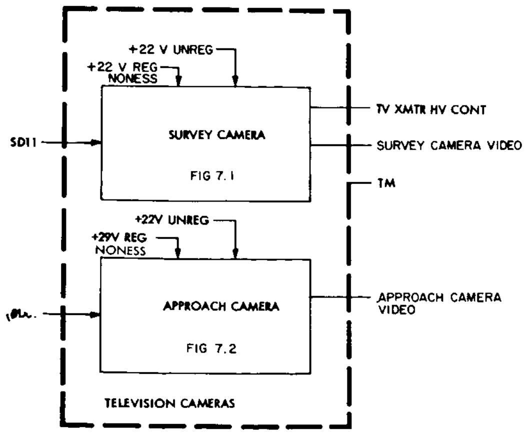
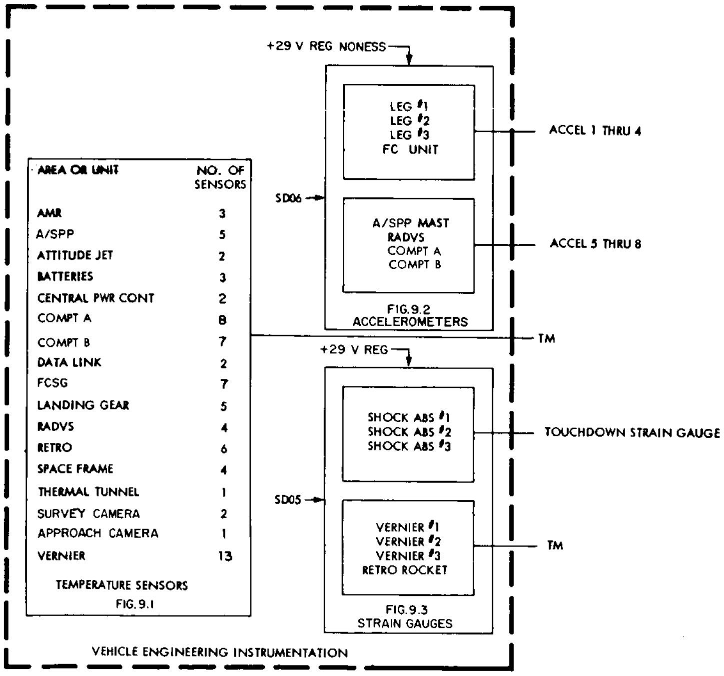


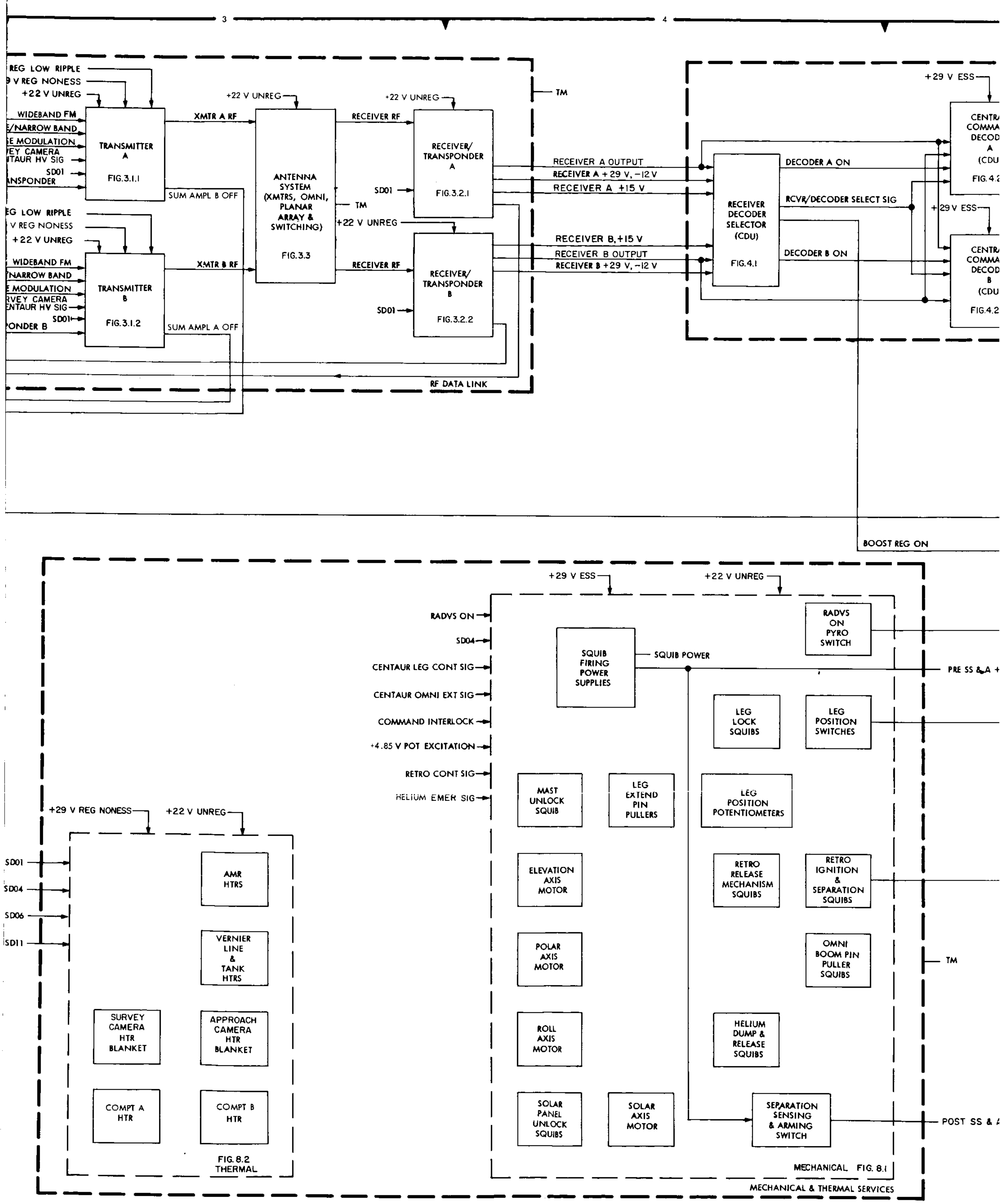
NOTE

1 ENGINEERING PAYLOAD

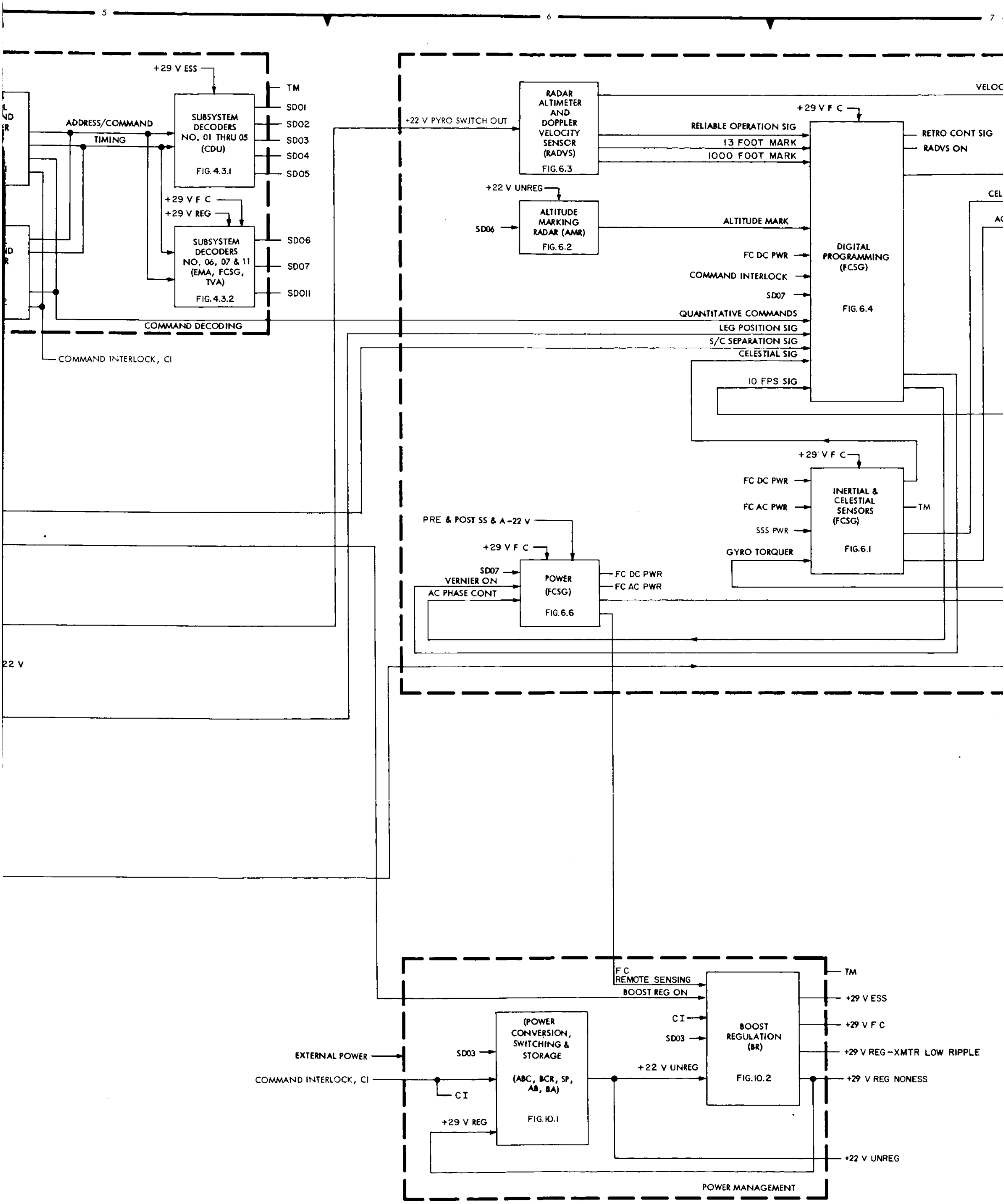
ITEM	FIGURE
ACCELEROMETERS NO. 5 THRU 8	9.2
AUXILIARY BATTERY	10.1
AUXILIARY BATTERY CONTROL	10.1
AUXILIARY ENGINEERING SIGNAL PROCESSOR	5.1, 5.3
CURRENT SHUNTS	10.1
STRAIN GAUGES	9.3
TEMPERATURE SENSORS (11)	9.1
TELEVISION AUXILIARY	4.3, 5.1, 5.4, 8.2
SURVEY TELEVISION CAMERA	7.1

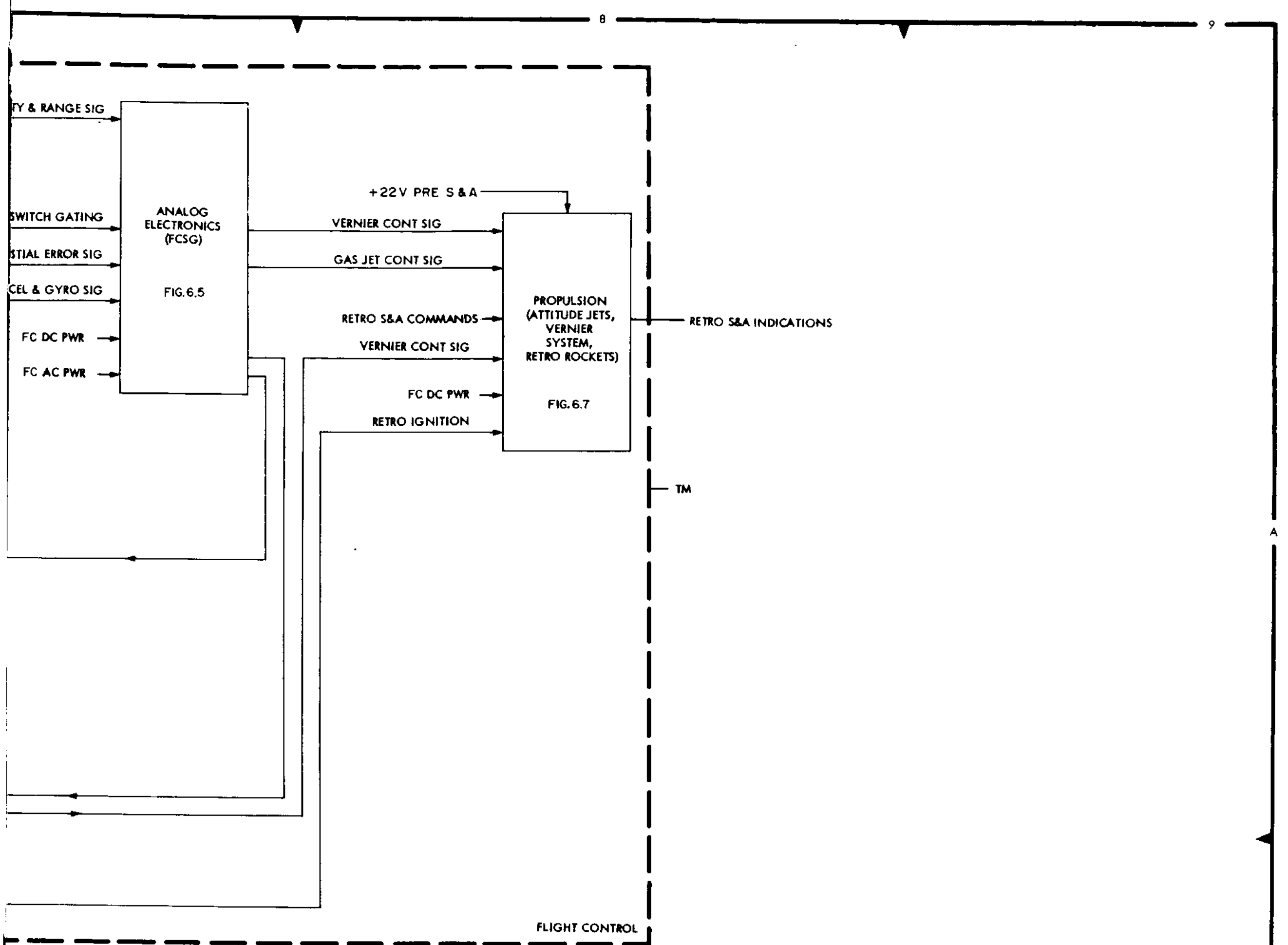






3
4
REG LOW RIPPLE
9 V REG NONESS
+22 V UNREG
WIDEBAND FM
/NARROW BAND
E MODULATION
EY CAMERA
TAUR HV SIG
SD01
NSPONDER
TRANSMITTER A
FIG.3.1.1
XMTR A RF
+22 V UNREG
ANTENNA SYSTEM (XMTRS, OMNI, PLANAR ARRAY & SWITCHING)
FIG.3.3
RECEIVER RF
+22 V UNREG
RECEIVER/ TRANSPONDER A
FIG.3.2.1
SD01
TM
SUM AMPL B OFF
+22 V UNREG
EG LOW RIPPLE
V REG NONESS
+22 V UNREG
WIDEBAND FM
NARROW BAND
E MODULATION
RVEY CAMERA
ENTAUR HV SIG
SD01
ONDER B
TRANSMITTER B
FIG.3.1.2
XMTR B RF
RECEIVER RF
RECEIVER/ TRANSPONDER B
FIG.3.2.2
SD01
SUM AMPL A OFF
RF DATA LINK
RECEIVER A OUTPUT
RECEIVER A +29 V, −12 V
RECEIVER A +15 V
RECEIVER B, +15 V
RECEIVER B OUTPUT
RECEIVER B +29 V, −12 V
RECEIVER DECODER SELECTOR (CDU)
FIG.4.1
DECODER A ON
RCVR/DECODER SELECT SIG
DECODER B ON
+29 V ESS
+29 V ESS
BOOST REG ON
+29 V ESS
+22 V UNREG
RADVS ON
SD04
CENTAUR LEG CONT SIG
CENTAUR OMNI EXT SIG
COMMAND INTERLOCK
+4.85 V POT EXCITATION
RETRO CONT SIG
HELIUM EMER SIG
SQUIB FIRING POWER SUPPLIES
SQUIB POWER
RADVS ON PYRO SWITCH
PRE SS & A
LEG LOCK SQUIBS
LEG POSITION SWITCHES
MAST UNLOCK SQUIB
LEG EXTEND PIN PULLERS
LEG POSITION POTENTIOMETERS
ELEVATION AXIS MOTOR
RETRO RELEASE MECHANISM SQUIBS
RETRO IGNITION & SEPARATION SQUIBS
POLAR AXIS MOTOR
OMNI BOOM PIN PULLER SQUIBS
TM
ROLL AXIS MOTOR
HELIUM DUMP & RELEASE SQUIBS
SOLAR PANEL UNLOCK SQUIBS
SOLAR AXIS MOTOR
SEPARATION SENSING & ARMING SWITCH
POST SS &
MECHANICAL FIG. 8.1
MECHANICAL & THERMAL SERVICES
+29 V REG NONESS
+22 V UNREG
SD01
SD04
SD06
SD11
AMR HTRS
VERNIER LINE & TANK HTRS
SURVEY CAMERA HTR BLANKET
APPROACH CAMERA HTR BLANKET
COMPT A HTR
COMPT B HTR
FIG.8.2 THERMAL


+29 V ESS
ADDRESS/COMMAND
TIMING
SUBSYSTEM DECODERS NO. 01 THRU 05 (CDU)
FIG. 4.3.1
TM
SD01
SD02
SD03
SD04
SD05
+29 V F C
+29 V REG
SUBSYSTEM DECODERS NO. 06, 07 & 11 (EMA, FCSG, TVA)
FIG. 4.3.2
SD06
SD07
SD011
COMMAND DECODING
COMMAND INTERLOCK, CI
+22 V PYRO SWITCH OUT
RADAR ALTIMETER AND DOPPLER VELOCITY SENSOR (RADVS)
FIG. 6.3
+22 V UNREG
SD06
ALTITUDE MARKING RADAR (AMR)
FIG. 6.2
+29 V F C
RELIABLE OPERATION SIG
13 FOOT MARK
1000 FOOT MARK
ALTITUDE MARK
FC DC PWR
COMMAND INTERLOCK
SD07
QUANTITATIVE COMMANDS
LEG POSITION SIG
S/C SEPARATION SIG
CELESTIAL SIG
10 FPS SIG
DIGITAL PROGRAMMING (FCSG)
FIG. 6.4
VELOC
RETRO CONT SIG
RADVS ON
CEL
AC
+29 V F C
FC DC PWR
FC AC PWR
SSS PWR
GYRO TORQUER
INERTIAL & CELESTIAL SENSORS (FCSG)
FIG. 6.1
TM
PRE & POST SS & A -22 V
+29 V F C
SD07
VERNIER ON
AC PHASE CONT
POWER (FCSG)
FIG. 6.6
FC DC PWR
FC AC PWR
22 V
F C
REMOTE SENSING
BOOST REG ON
CI
SD03
EXTERNAL POWER
COMMAND INTERLOCK, CI
SD03
CI
+29 V REG
(POWER CONVERSION, SWITCHING & STORAGE (ABC, BCR, SP, AB, BA)
FIG. 10.1
+22 V UNREG
BOOST REGULATION (BR)
FIG. 10.2
TM
+29 V ESS
+29 V F C
+29 V REG-XMTR LOW RIPPLE
+29 V REG NONESS
+22 V UNREG
POWER MANAGEMENT



UNCLASSIFIED		
HUGHES	SPACE SYSTEMS DIVISION HUGHES AIRCRAFT COMPANY EL SEGUNDO, CALIF.	
PREPARED BY: M. Robinson	DATE 10-20-63	SURVEYOR SPACECRAFT A21
APPROVED BY: R.A. Pietropaolo	DATE 10-28-63	DRAWING CONTROL NO. 5-968-38 — REV G

Figure 2.1. Surveyor System, Functional Block Diagram

SECTION III

RF DATA LINK

This section contains functional block diagrams and general functional theory for the RF DATA LINK FUNCTION. Functional schematic diagrams and functional theory are included in Section III of Volume II.

3.0 R.F. DATA LINK. (Fig. 3.0)

Prepared by J L Han date 17 Nov 64

Approved by E. L. Thompson date 17 Nov. 1964

3.1 Receivers A and B

3.2 GENERAL

The Receivers consist of two identical Receiver-Transponder units, A and B, each composed of solid state devices, cavities and attenuators. The purpose of the Receivers is to receive commands from ground control and to provide for doppler tracking (Transponder operation) of the spacecraft while it is in transit. Transponder operation is discussed in paragraph 3.16.

Both receivers operate continuously throughout the life of the spacecraft to provide constant command capability. The outputs of both receivers are connected to the Central Decoder Unit (CDU). Each receiver is permanently connected to an Omni Directional Antenna thru a diplexer. Transponder interconnection circuits are provided that permit each receiver to be connected to a transmitter for transponder operation wherein the transmitted signal is in phase coherence with the received signal.

The Receivers normally operate as crystal-controlled double-conversion frequency-modulation receivers. Commands from ground control are frequency modulated on a subcarrier which in turn phase modulates the main carrier of the earth-to-spacecraft transmissions. The main discriminator in the receiver detects the subcarrier signal. The detected signal is then applied to a subcarrier discriminator which recovers the digitized command signals and supplies them to the COMMAND DECODING FUNCTION.

3.3 OPERATIONAL REQUIREMENTS.

Receiver/Transponder A and B are activated prior to launch by application of "+22 V Unreg" permitting the reception of commands from ground control. The commands are sent by ground control to activate and check the operation of the various systems within the spacecraft prior to launch and throughout the life of the spacecraft.

3.4 OPERATIONAL THEORY.

The Receiver Section of the Receiver/Transponder provides six outputs, as follows:

(1) RECEIVER A COMMAND OUTPUT or RECEIVER B COMMAND OUTPUT - digitized commands supplied to the Receiver Decoder Selector, and both Central Command Decoders.

(2) RECEIVER A AFC D16 or RECEIVER B AFC D17 - supplied to ESP Voltage Measurement Commutation for processing into a word, which is transmitted to ground control. This information is used by ground control to check the operation of the receivers.

(3) RECEIVER A AGC D9 or RECEIVER B AGC D10 - supplied to ESP Voltage Measurement Commutation for processing into a word, which is transmitted to ground control. This information is used by ground control to check the operation of the receivers.

(4) RECEIVER A +15 V or RECEIVER B +15 V - supply voltage for the Receiver Decoder Selector.

(5) RECEIVER A +29 V or RECEIVER B +29 V - supply voltage for the Receiver Decoder Selector.

(6) RECEIVER A -12 V or RECEIVER B -12 V - supplied to the Central Command Decoders for use as a bias voltage.

The receiver portion of the Receiver/Transponder receives two inputs:

(1) RECEIVER RF - a 2113-mc signal transmitted by ground control. This signal is composed of a carrier signal phase modulated by the command subcarrier, which in turn is frequency modulated by the command information.

(2) 22 V UNREG - supply voltage from Power Conversion, Switching, and Storage.

3.5 Local Oscillator and Multiplication.

The purpose of the LOCAL OSCILLATOR and X6 VARACTOR CAVITY MULTIPLIER is to provide a local oscillator frequency and to multiply this frequency for mixing with the signal transmitted by ground control.

The LOCAL OSCILLATOR and X6 VARACTOR CAVITY MULTIPLIER provides three outputs: a 2066-mc local oscillator signal supplied to the CAVITY MIXER for mixing with the transmitted signal, a 19-mc signal supplied to the X2 MULTIPLIER to be multiplied and mixed to produce the second IF, and a 19-mc signal supplied to the AMPL for Transponder operation.

The LOCAL OSCILLATOR has two inputs: the automatic frequency control (AFC) and the automatic phase control (APC). During FM operation the frequency of the LOCAL OSCILLATOR is controlled by the AFC from the FIRST DISCRIMINATOR. The frequency of the LOCAL OSCILLATOR is controlled by the APC from the PHASE DETECTOR during Transponder operation.

The LOCAL OSCILLATOR is phase locked to the received signal. The 19 mc output signal of the oscillator is multiplied to 344 mc and applied to the LC FILTER. The LC FILTER matches the LOCAL OSCILLATOR output to the X6 VARACTOR CAVITY MULTIPLIER. The X6 VARACTOR CAVITY MULTIPLIER multiplies the 344-mc local oscillator frequency by six to give an output frequency of 2066 mc. The 2066-mc local oscillator frequency is applied to the CAVITY MIXER.

3.6 Mixing.

The purpose of the CAVITY MIXER is to mix the local oscillator frequency with the received signal to produce the first IF frequency. The CAVITY MIXER has two inputs, the 2113-mc received signal from the antenna and the 2066-mc local oscillator signal from the X6 VARACTOR CAVITY MULTIPLIER. The mixing action of the CAVITY MIXER produces a frequency of 47 mc. This 47-mc first IF signal is applied to the FIRST IF AMPLIFIER.

3.7 IF AMPLIFICATION.

3.8 FIRST IF AMPLIFIER. The purpose of the FIRST IF AMPLIFIER is to filter and amplify the first IF frequency.

The two outputs from the FIRST IF AMPLIFIER are the amplified first IF, which is supplied to the MIXER and the "Receiver A AGC, D9," which is derived from feedback from the SECOND IF AMPLIFIER and is supplied to ESP Voltage Measurement Commutation for processing into a word that is transmitted to ground control.

The FIRST IF AMPLIFIER has two inputs: the first IF from the CAVITY MIXER and the AGC from the SECOND IF AMPLIFIER, which maintains the output of the FIRST IF AMPLIFIER at a fairly constant level for the following stages.

The 47-mc IF signal output from the CAVITY MIXER is applied to the FIRST IF AMPLIFIER. The AGC maintains the output of the FIRST IF AMPLIFIER at a fairly constant level for the succeeding stages. The "Receiver AGC D9" output is supplied to ESP Voltage Measurement Commutation for processing into part of a word to be transmitted to ground control as a check on the operation of the receiver.

3.8A. SECOND IF MIXER. The purpose of the SECOND IF MIXER is to combine the output of the FIRST IF AMPLIFIER and X2 MULTIPLIER and produce the second IF.

The SECOND IF MIXER has two inputs. One is a 47-mc signal from the FIRST IF AMPLIFIER and the other is a 38-mc signal from the X2 MULTIPLIER. The mixing of these signals produces the second IF of 9.6 mc. The 9.6-mc output is applied to the SECOND IF AMPLIFIER.

3.9 SECOND IF AMPLIFIER. The purpose of the SECOND IF AMPLIFIER is to amplify and limit the second IF signal. The SECOND IF AMPLIFIER delivers three outputs: the 9.6-mc second IF signal supplied to the FIRST DISCRIMINATOR, the AGC signal supplied to the FIRST IF AMPLIFIER, and the "2nd IF Limited" signal supplied to the PHASE DETECTOR for Transponder operation.

3.10 Discrimination.

3.11 FIRST DISCRIMINATOR. The purpose of the FIRST DISCRIMINATOR is to recover the subcarrier containing the command modulation and to provide automatic frequency control for the VCXO when not in transponder operation.

The three outputs from the FIRST DISCRIMINATOR are the command subcarrier, which is supplied to the SECOND DISCRIMINATOR; the AFC, which is supplied to the VCXO to control its frequency; and "Receiver A AFC, D16," which is supplied to ESP Voltage Measurement Commutation.

3.12 SECOND DISCRIMINATOR. The purpose of the SECOND DISCRIMINATOR is to recover the command information from the subcarrier and to supply the command information to the Receiver Decoder Selector in a usable form. The SECOND DISCRIMINATOR has a single output, the command information, "Receiver A Command Output".

The command subcarrier output from the FIRST DISCRIMINATOR is amplified, the coded frequency modulation of the subcarrier is converted to coded amplitude variations and applied to the Receiver Decoder Selector.

3.13 Voltage Converters.

3.14 REGULATING DC-TO-DC CONVERTER. The purpose of the REGULATING DC-TO-DC CONVERTER is to supply a constant voltage for the Receiver/ Transponder and Receiver Decoder Selector, and to provide excitation for the ECU (DC TO DC CONVERTER).

The "Receiver +15 V" signal is supplied to the TRANSPONDER PWR SWITCH, to the ECU (DC TO DC CONVERTER) as an excitation voltage, to the Receiver Decoder Selector as a supply voltage, and throughout the Receiver/ Transponder as a supply voltage.

The only input to the REGULATING DC-TO-DC CONVERTER is the "22 V Unreg" from Optimum Charge Regulation, which is initially applied prior to launch and is continuously applied throughout the life of the spacecraft. The output of REGULATING DC-TO-DC CONVERTER is 15 vdc.

The "Receiver +15 V"output from REGULATING DC-TO-DC CONVERTER is applied throughout the Receiver/Transponder as a supply voltage. The "Receiver +15 V" is also applied to the ECU (DC TO DC CONVERTER) as an excitation voltage, to the TRANSPONDER PWR SWITCH, and to the Receiver Decoder Selector as a supply voltage.

3.15 ECU (DC TO DC CONVERTER). The purpose of this stage is to supply voltages to the Receiver-Decoder Selector portion of the Central Decoder Unit.

The three outputs of the ECU (DC TO DC CONVERTER) are the "Receiver A +29 V" or "Receiver B +29 V," which is a supply voltage for the Receiver Decoder Selector, the "Receiver A -12 V" or "Receiver B -12 V",which is used as a bias voltage in the Central Command Decoder, and the "-12 V Receiver" applied to the AMP in the SECOND DISCRIMINATOR to prevent stray voltages from being applied to the Receiver Decoder Selector.

The only input to the ECU (DC TO DC CONVERTER) is the "Receiver +15 V" from the REGULATING DC-TO-DC CONVERTER which activates the ECU (DC TO DC CONVERTER).

The "Receiver +15V" is chopped, rectified and filtered. The "Receiver A +29 V" or "Receiver B +29 V" output is supplied along with the "Receiver A -12 V or "Receiver B -12 V" output to the Receiver Decoder Selector in the Central Decoder Unit.

3.16 TRANSPONDERS A AND B.

3.17 GENERAL.

The transponders consist of two identical transponder interconnections, each composed of solid state circuits located in Receiver/Transponder A and Receiver/Transponder B. The purpose of the transponder, operating in conjunction with a receiver and a transmitter, is to provide a phase coherent system for doppler tracking of the spacecraft during transit. There are two complete receiver-transponder-transmitter systems to ensure reliability.

3.18 OPERATIONAL REQUIREMENTS.

The combination of Transmitter B and Receiver/Transponder B is normally operated as a transponder during transit by means of the transponder connections in Receiver/Transponder B. In the event of a failure in the B system, another identical set of transponder interconnections may be used to connect Transmitter A and Receiver/Transponder A for transponder operation.

The transponder interconnections may be used prior to launch since power for the transponder interconnections is supplied by the receiver REGULATING DC-TO-DC CONVERTER, which is activated prior to launch by "22 V Unreg" power. Transponder operation is activated prior to launch by the "Xponder B Pwr On, 0123" command from SSD1 applied to Receiver/Transponder B. Phase-lock is achieved during the DSIF acquisition mode for doppler tracking of the spacecraft. During transponder operation, the receiver VCXO replaces the transmitter VCXO and the receiver VCXO carrier signal is phase modulated by the engineering data.

3.19 OPERATIONAL THEORY.

The transponder interconnections have three outputs as follows:

(1) REC VCXO (RF) AND PHASE LOCK (DC) - switching signal (d-c) and receiver VCXO local oscillator signal supplied to the transmitter. The d-c phase-lock signal switches off the transmitter VCXO. The receiver VCXO local oscillator signal is used to supply the transmitter carrier signal.

(2) STATIC PHASE ERROR A, D7 - a d-c signal supplied to ESP Voltage Measurement Commutation for processing and transmission to ground control. This signal provides frequency correction information for the ground transmitter.

(3) XPONDER A PHASE LOCKED, D5 - a d-c signal supplied to ESP Digital Word Assembly for processing and transmission to ground control. This signal indicates when phase-lock is achieved.

The transponder interconnections have six inputs as follows:

(1) XPONDER A PWR ON, 0122 or XPONDER B PWR ON, 0123 - command from SSD1 that switches on the transponder interconnections.

(2) XPONDER PWR OFF, 0124 - command from SSD1 that switches off the transponder interconnections.

(3) XPONDER +15 V - supply voltage for the transponder interconnections from the receiver REGULATING DC-TO-DC CONVERTER, which is applied through the TRANSPONDER PWR SWITCH when the transponder interconnections are commanded on.

(4) RECEIVER +15 V - an inhibiting voltage from the receiver REGULATING DC-TO-DC CONVERTER applied to the TRANSMITTER DRIVER to prevent the receiver VCXO signal from being supplied to the transmitter when the transponder interconnections are switched off.

(5) 19-MC LO - receiver VCXO local oscillator signal that is used to replace the transmitter VCXO Local Oscillator signal. This signal also provides the PHASE DETECTORS with one of the r-f inputs necessary for phase detection, after proper frequency division.

(6) 2nd IF (LIMITED) - a 9.6-mc signal from the SECOND IF AMPLIFIER supplied to the PHASE DETECTORS as a reference signal.

3.20 Command Inputs.

The operational theory for the transponder is presented in the following paragraphs in conjunction with the commands that are sent by ground control.

3.21 XPONDER A PWR ON 0122. The purpose of this command is to switch on the TRANSPONDER PWR SWITCH that provides supply voltage for the transponder interconnections during transponder operation.

The "Xponder A Pwr On, 0122" command produces a "Xponder +15 V" signal. The "Xponder +15 V" signal activates the transponder interconnections. The "Xponder +15 V" is also applied to the FIRST DISCRIMINATOR, to conduct and clamp the AFC to +5 v.

The "19 MC LO" signal from the LOCAL OSCILLATOR is applied to a tuned amplifier. The 19-mc output of the AMP is applied to the TRANSMITTER DRIVER and to another tuned amplifier. The amplifier 19-mc output of the second AMP is applied to the X 1/2 VARACTOR MULTIPLIER, which consists of two varactors. The X 1/2 VARACTOR MULTIPLIER divides the input frequency by two, producing an output frequency of 9.6 mc, which is applied to the QUADRATURE PHASE DETECTOR and to the PHASE DETECTOR.

The 9.6-mc signal applied to the PHASE DETECTOR is shifted +45 degrees and used as an error signal. The "2nd IF (Limited)" reference signal from the SECOND IF AMPLIFIER is applied to the PHASE DETECTOR and amplified. The 9.6-mc reference signal from the SECOND IF AMPLIFIER is detected against the 9.6-mc error signal from the X 1/2 VARACTOR MULTIPLIER and the resultant d-c output of the PHASE DETECTOR is supplied to ESP Voltage Measurement Commutation as the "Static Phase Error A, D7" signal. This d-c signal is processed and transmitted to ground control to provide frequency correction information for the ground transmitter. The resultant d-c output of the PHASE DETECTOR is also applied to the LOCAL OSCILLATOR as the "Automatic Phase Control" (APC) signal. The d-c output signal, APC, of the PHASE DETECTOR is close to zero volt when the phase difference between the error signal and the reference signal is very small and increases when the phase difference between the error signal and the reference signal increases in order to force the phase of the VCXO frequency to remain phase-locked with the received signal.

The 9.6-mc signal applied to the QUADRATURE PHASE DETECTOR, shifted -45 degrees and used as an error signal. The "2nd IF (Limited)" 9.6-mc signal from the SECOND IF AMPLIFIER is amplified and used as a reference signal. When the phase difference between the 9.6-mc error signal and 9.6-mc reference signal is negligible, which indicates that the loop is phase-locked, the d-c output of the PHASE DETECTOR will go positive and feed into the TRANSMITTER DRIVER. The signal is amplified, filtered and sent to ESP Digital Word Assembly as the "Xponder A Phase-Locked, D5" signal. The "Xponder A Phase-Locked D5" signal is processed and transmitted to ground control as an indication that phase-lock has been achieved.

The d-c output of the first AMP is sent to the TRANSMITTER DRIVER where it is attenuated and sent to the NARROW BAND VCXO PM AND FM MODULATOR of Transmitter A.

3.22 XPONDER PWR OFF. The purpose of this command is to switch off the TRANSPONDER PWR SWITCH, which in turn removes the supply voltage from the transponder interconnections. The "Transponder +15 V" clamping voltage is removed from the FIRST DISCRIMINATOR, allowing the AFC to resume control of the VCXO.

3.23 Transmitters A and B.

3.24 GENERAL.

The Transmitter function consists of two identical transmitters, A and B. The Transmitters may be switched so that either may use the high-gain Planar Array or the Omni-Directional Antennas, providing a complete and redundant Transmitter function. Each Transmitter consists of solid state circuits, mechanical switches, attenuators, isolators, and a traveling-wave tube (TWT). The purpose of this function is to transmit the following information to the DSIF:

1. Engineering data during transit and lunar phases.

2. Scientific data during lunar operations.

3. Verification of all commands received from the DSIF during transit and lunar phases.

4. Doppler tracking signal during transit.

5. Television data during descent and lunar phases.

3.25 OPERATIONAL REQUIREMENTS.

Transmitter A is used as the standby transmitter and is activated when Transmitter B fails. Transmitter low power must be turned on before high power can be turned on. Transmitter B is activated prior to launch by application of commands from Subsystem Decoder No. 1, which permits the transmission of engineering data and verification of commands received to ground control while the spacecraft is still on the launch pad. This information is required by ground control during operational checkout of the Surveyor System. The transmitters may be used as long as the "+29 V Regulated Non Essential" power is available. The "+22 V Unregulated" is required to operate the relays for switching between high and low power operation and for the antenna transfer switches.

The Transmitters are capable of operating in several modes during the functional modes of transit. The different operating and functional modes are as follows:

1. High Power Mode - utilizes the TWT to provide 10 watts of output power for transmission of high rate interrogation reply to ground control during transit and transmission of television data (1 sec/frame) to ground control during descent.

2. Low Power Mode - provides 100 milliwatts of output power for transmission of engineering data throughout all phases of the operation.

3. Normal Mode - transmits wideband PM at either high or low power.

4. Emergency Mode - activated in the event of marginal reception at the ground station. In this mode the transmission of engineering and television data (20 sec/frame) is via the narrow band frequency modulator on low power.

5. Transponder Mode - transmitter narrow band voltage controlled crystal oscillator (VCXO) is replaced by the receiver local oscillator to provide a phase-coherent system for doppler tracking of the spacecraft by ground control during transit. Refer to paragraph 3-16 for Transponder Operation.

FUNCTIONAL MODES

I. Prior to Launch - Transmitter A is checked out and Transmitter B is activated. Engineering data is transmitted by Transmitter B to ground control in Normal Mode at low power.

II. Launch to Separation - engineering data transmitted to ground control in the Normal Mode at low power.

III. DSIF Acquisition - engineering data transmitted to ground control in Normal Mode at high power. Transmitter narrow band VCXO is replaced by the receiver local oscillator to provide a phase coherent system for doppler tracking of the spacecraft by ground control.

IV thru IX. Attitude Reference Acquisition through Coast Mode II - engineering data transmitted to ground control in Normal Mode at low power with short intervals of Normal Mode at high power operation for high data rate transmission to ground control. Receiver local oscillator is used to provide a phase coherent system for doppler tracking of the spacecraft by ground control.

X thru XII. Pre-Retro Maneuver through Vernier Descent to Start of Lunar Sequence-time shared television and engineering data transmitted to ground control in Normal Mode at high power. Receiver local oscillator replaced by transmitter wideband VCXO.

3.26 OPERATIONAL THEORY.

3.27 Output Signals.

There are three output signals associated with the Transmitters; two are digital, "Transmitter Filament On andTransmitter Summing Amplifier Gate On." The third signal is the Transmitter modulated carrier identified as "Xmtr 49 or 50 Rf Output." These output signals are described as follows:

1. XMTR 49 RF OUTPUT or XMTR 50 RF OUTPUT - has several configurations depending upon the operating and functional mode. These output configurations are as follows:

   a. Phase modulated engineering data at 2295 mc prior to and during launch. The carrier signal is supplied by the "Narrow Band VCXO PM and FM Modulator." This signal is low power 100 milliwatt output.

b. Wideband engineering data, phase-modulated, 2295-mc output signal during transit. This is a low power 100-milliwatt output signal, except during high bit rate interrogation reply to ground control, then the output is commanded to a high power 10-watt signal. The carrier signal is supplied by the receiver local oscillator for phase-locked transponder operation.

c. Wideband frequency-modulated, 2295-mc, 10-watt output signal during and after descent. The frequency modulation is time shared television and engineering data. The carrier signal is supplied by the Wideband VCXO PM and FM Modulator.

d. Narrow-band, frequency-modulated, 2295-mc, 100-milliwatt output signal during Emergency TV operation when bandwidth limiting is necessary for signal reception. The carrier signal is supplied by the Narrow Band VCXO PM and FM Modulator.

2. XMTR A FILAMENT ON or XMTR B FILAMENT ON - sent to ESP Digital Word Assembly for processing into a word, which is then transmitted to ground control to indicate that transmitter A or B traveling wave tube filaments have been turned on.

3. XMTR A SUM AMPL GATE, - ON- or XMTR B SUM AMPL GATE, -ON- - sent to Summing Amplifiers to prevent Transmitter A from receiving FM or PM data from the Summing Amplifiers when Transmitter B is operating and vice versa.

3.28 FUNCTIONAL THEORY.

The operational theory for the transmitters is presented in the following paragraphs in conjunction with the commands that are sent by ground control.

3.29 LOW POWER CONTROL.

The "Transmitter A Low Power On" command from Subsystem Decoder No. 1 (SSD1) applied to the XMTR LOW PWR CONTROL permits power to be applied to the transmitter for operational checkout, transmission of engineering data via wideband FM and verification of commands received.

The "XMTR A Low Pwr On," command from SSD1 applied to the XMTR LOW PWR CONTROL, provides a low impedance path for "+29 V Low Ripple" from Boost Regulation. This +29 V output is applied throughout the transmitter as the "Xmtr +29 V" supply voltage and to the Summing Amplifiers as "Sum Ampl Gate" to prevent Transmitter B from receiving FM or PM data from the Summing Amplifiers when Transmitter A is operating. The +29 V output is also applied to the NARROW BAND VCXO CONTROL.

Should the occasion arise that the transmitter must be turned off, the "Xmtr Low Pwr Off" command from SSD1 will be applied to the XMTR LOW PWR CONTROL to remove or cut off the "Xmtr +29 V" supply voltage.

3.30 NARROW BAND VCXO CONTROL. The "Narrow Band VCXO On" command from SSD1 applied to the NARROW BAND VCXO CONTROL permits the application of supply voltage to the NARROW BAND VCXO PM AND FM MODULATOR and disables the WIDEBAND VCXO PM AND FM MODULATOR.

The "Narrow Band VCXO On," command from SSD1 applied to the NARROW BAND VCXO CONTROL allows the "Xmtr +29 V" to pass through and become the "NB VCXO +29 V" signal. The "NB VCXO +29 V" output voltage is applied to the NARROW BAND VCXO PM AND FM MODULATOR as a supply voltage, and to the WIDEBAND VCXO PM AND FM MODULATOR as an inhibiting bias voltage.

A "Narrow Band VCXO Off" command from the SSD1 is applied to the NARROW BAND VCXO CONTROL to disable the NARROW BAND VCXO PM AND FM MODULATOR for transmission of time shared wideband television and engineering data.

3.31 HIGH POWER NETWORK.

The HIGH POWER NETWORK channels signals to HV ECU SWITCHING and XMTR HIGH/LOW PWR CONTROL. The "Xmtr A High Volt On" command from SSD1 is applied to HV ECU SWITCHING for high power operation of the transmitter. The "Xmtr High Voltage On - Centaur" command from Centaur Flight Control Programmer is applied to HV ECU SWITCHING just prior to separation to ensure that the necessary signal strength is available for initial DSIF acquisition. The "Xmtr High Voltage On - Centaur" command is also sent to the XMTR HIGH/LOW PWR CONTROL. The "Xmtr A and B High Voltage On" signal from TV3 Survey Camera Video Logic is also applied to HV ECU SWITCHING for high power operation.

3.32 NARROW BAND VCXO PM AND FM MODULATOR.

In the Transponder Mode, the "Rec VCXO (RF) and Phase Lock (DC)" signal is phase modulated with "Phase Modulation Xmtr B" engineering data. When not in the Transponder Mode, the "TV Input Wide/Narrow Band" signal is phase modulated with the "Phase Modulation Xmtr A" engineering data. Its output is applied to the FREQUENCY MULTIPLIER.

3.33 WIDEBAND VCXO PM AND FM MODULATOR.

The "TV Input Wide/Narrow Band" signal is phase modulated with the "Wideband FM Xmtr A" engineering data input. Its output is applied to the FREQUENCY MULTIPLIER.

3.34 FREQUENCY MULTIPLIER.

The FREQUENCY MULTIPLIER multiplies the 19-mc carrier plus PM or FM by five and removes any existing amplitude modulation. The modulated carrier output is applied to the FREQUENCY DOUBLERS.

3.35 FREQUENCY DOUBLERS.

The FREQUENCY DOUBLERS amplifies the input signal and doubles its frequency twice. The output signal is sent to the RF FILTER.

3.36 RF FILTER, X2 AND X3 VARACTOR STRIPLINE MULTIPLIER, AND ISOLATOR.

The filter network reduces unwanted frequencies from being delivered to or reflected from the next stage. The X2 AND X3 VARACTOR STRIPLINE MULTIPLIER multiplies the carrier signal by two and then by three. The resultant output is applied through the ISOLATOR to the TRAVELING WAVE TUBE AND TRANSFER SWITCH.

3.37 HV ECU SWITCHING.

The "Hv On" signal permits HV ECU SWITCHING to activate the HIGH VOLTAGE ECU. A "Hv Off" or "Low Pwr Interlock" signal deactivates the HIGH VOLTAGE ECU.

3.38 HIGH VOLTAGE ECU.

The HIGH VOLTAGE ECU generates and applies TWT high voltages for high power transmission. The "Xmtr A Filament On" voltage is applied to the HIGH VOLTAGE ECU as a biasing voltage. The HIGH VOLTAGE ECU, activated by HV ECU SWITCHING produces "+60 V", "-425 V", "-1250 V", and "Hv Ret" signals. These output signals are sent to the TRAVELING WAVE TUBE AND TRANSFER SWITCH.

3.39 TWT FILAMENT ECU.

The "Xmtr A Fil Pwr On" command from SSD1 applied to the TWT FILAMENT ECU permits the application of filament voltage to the TRAVELING WAVE TUBE in preparation for high power transmission. The "Xmtr Fil Pwr Off" command removes the filament voltage.

The "TWT Filament" outputs of TWT FILAMENT ECU are outputs of transformers. These outputs are applied to the filaments of the TRAVELING WAVE TUBE. The "Xmtr A Filament On" output is sent to ESP Digital Word Assembly for processing, then transmitted to ground to indicate that Transmitter A TWT filaments have been turned on. The "Xmtr A Filament On" output is also sent to the HIGH VOLTAGE ECU and HV ECU SWITCHING as biasing voltages.

3.40 XMTR HIGH/LOW PWR CONTROL, TRAVELING WAVE TUBE AND TRANSFER SWITCH.

The "Xfer Sw High Pwr" command from SD1 or the "High Pwr Command" from the HIGH POWER NETWORK causes the TRAVELING WAVE TUBE to be switched into the output circuitry of the transmitter for high power amplification of the transmitter output. The "High Pwr Command" also generates the "Low Pwr Interlock" signal which is sent to the HIGH VOLTAGE ECU. The "Xfer Sw Low Pwr" command from SD1 causes the low power output of the transmitter to be applied to the selected antenna. The "+60 V", "-1250 V", and "-425 V" outputs from the HIGH VOLTAGE ECU are applied to the anode, cathode and collector of the TRAVELING WAVE TUBE respectively. The "TWT Filament" outputs from the TWT Filament ECU is applied to the filaments of the TRAVELING WAVE TUBE.

3.41 Antenna System.

3.42 TRANSMITTER PLANAR ANTENNA CONTROL and ANTENNA TRANSFER SWITCH.

The TRANSMITTER PLANAR ANTENNA CONTROL is a control that allows signals from Transmitter A or B to be sent to the PLANAR ARRAY ANTENNA. When the "Xmtr B to Planar" signal is present, a +22 v "Ant. Xfer Sw, Xmtr B to Planar" signal is sent to the ANTENNA TRANSFER SWITCH. When the "Xmtr A to Planar" signal is present, a +22 v "Ant Xfer Sw, Xmtr A to Planar" signal is sent to the ANTENNA TRANSFER SWITCH. The "Ant. Xfer Sw, Xmtr B to Planar" signal connects the "Xmtr B Rf Output" from Transmitter B to the PLANAR ARRAY ANTENNA and Transmitter A to the OMNI ANTENNA A or B. The "Ant Xfer Sw, Xmtr A to Planar" signal connects the "Xmtr A Rf Output" from Transmitter A to the PLANAR ARRAY ANTENNA and Transmitter B to OMNI ANTENNA A or B

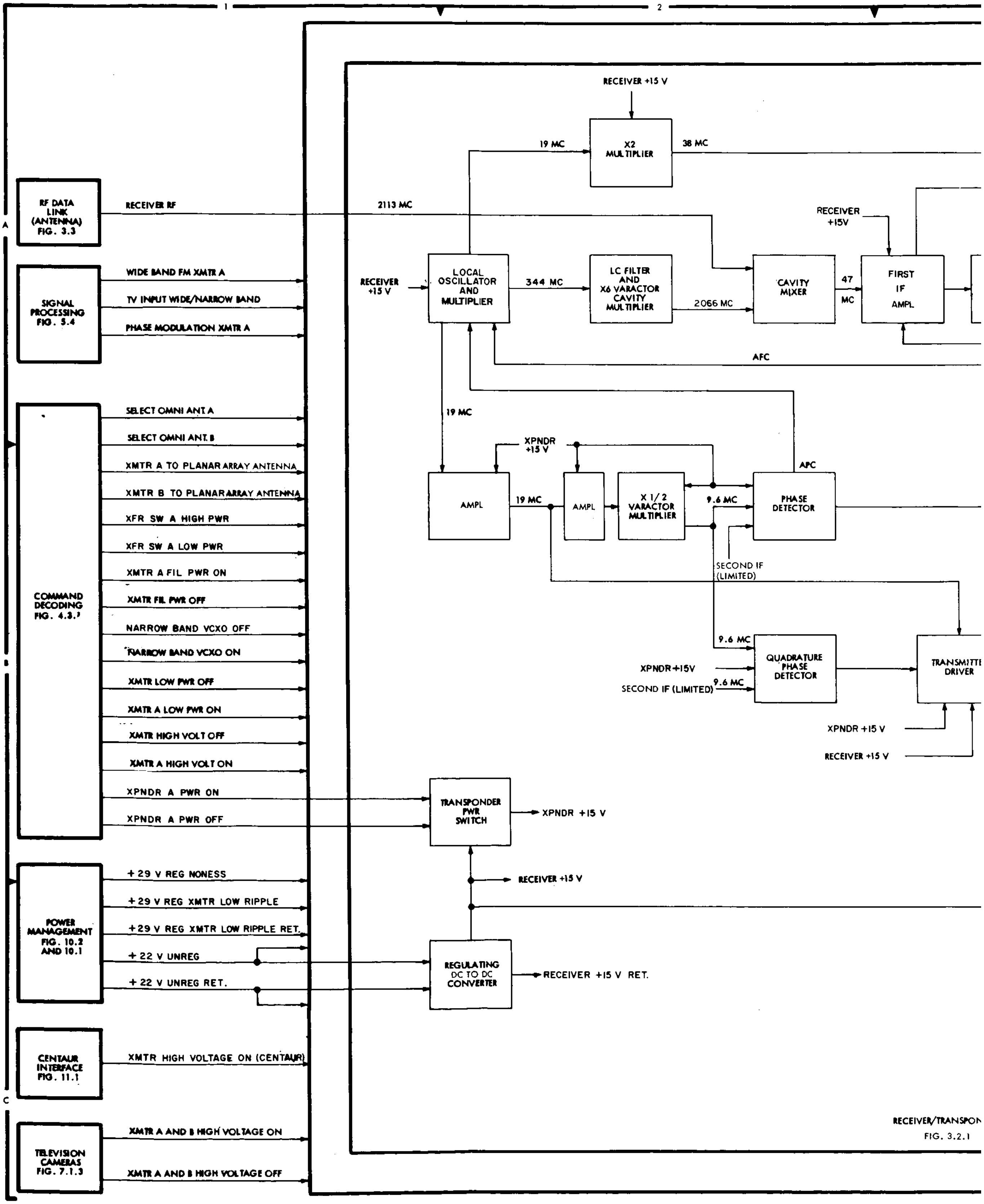
3.43 TRANSMITTER B OMNI ANTENNA CONTROL and OMNI ANTENNA SELECTION.

The TRANSMITTER B OMNI ANTENNA CONTROL allows signals from Transmitter A or B to be sent to OMNI ANTENNA A or B. The "Select Omni Ant A" signal triggers a +22 v "SPDT to Omni Ant. A" signal to the OMNI ANTENNA SELECTION. The "Select Omni Ant. B" signal triggers a +22 v "SPDT to Omni Ant B" signal to the OMNI ANTENNA SELECTION. The "SPDT to Omni Ant B" signal connects the output of the "RF Transmitted" from Transmitter A or B to OMNI ANTENNA B. The "SPDT to Omni Ant. A" signal connects the output of "RF Transmitted" from Transmitter A or B to OMNI ANTENNA A. This should be used when the OMNI ANTENNA B system is not functioning properly or is not properly positioned with respect to ground control.

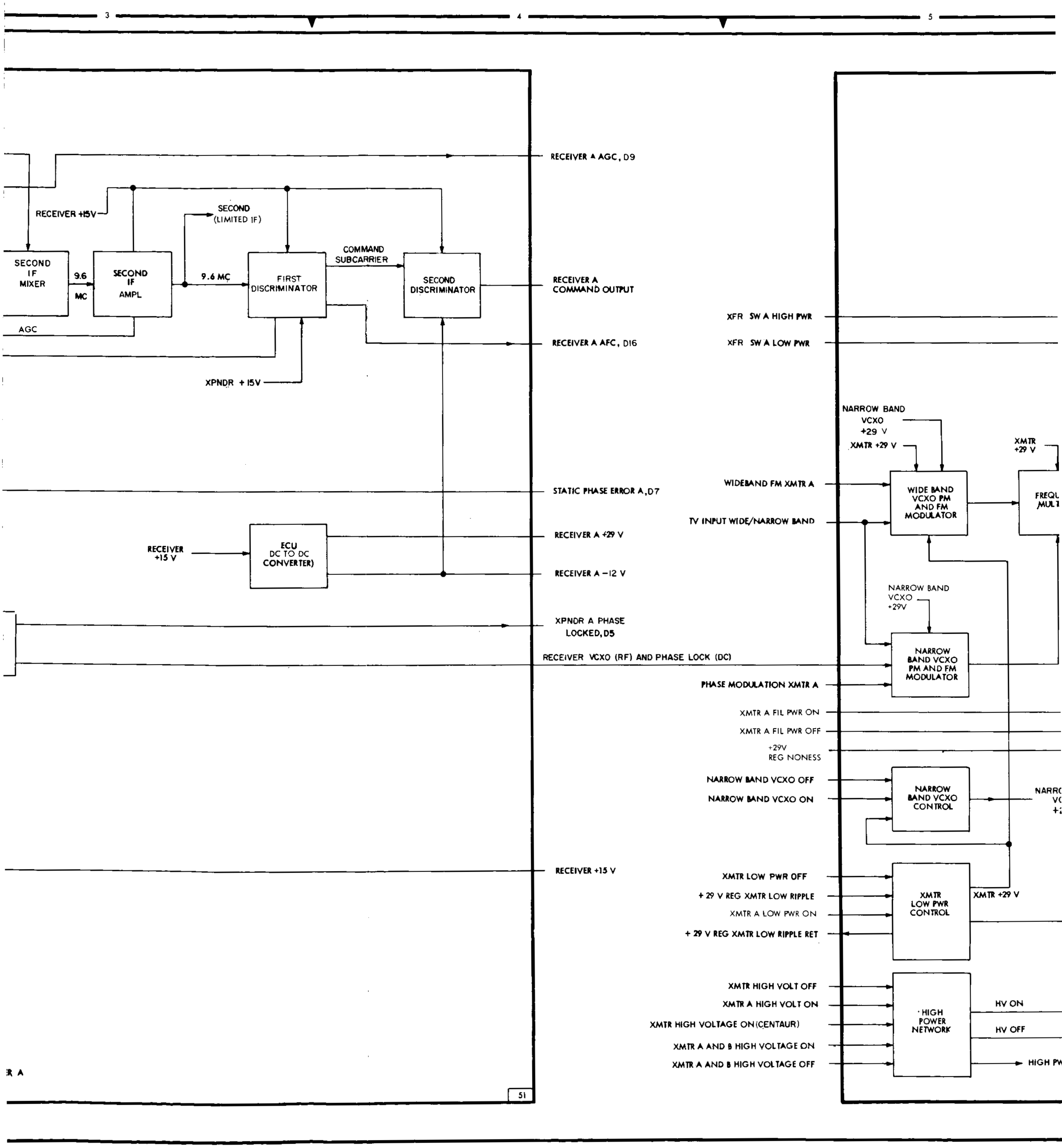
3.44 DIPLEXER and OMNI ANTENNA A and B.

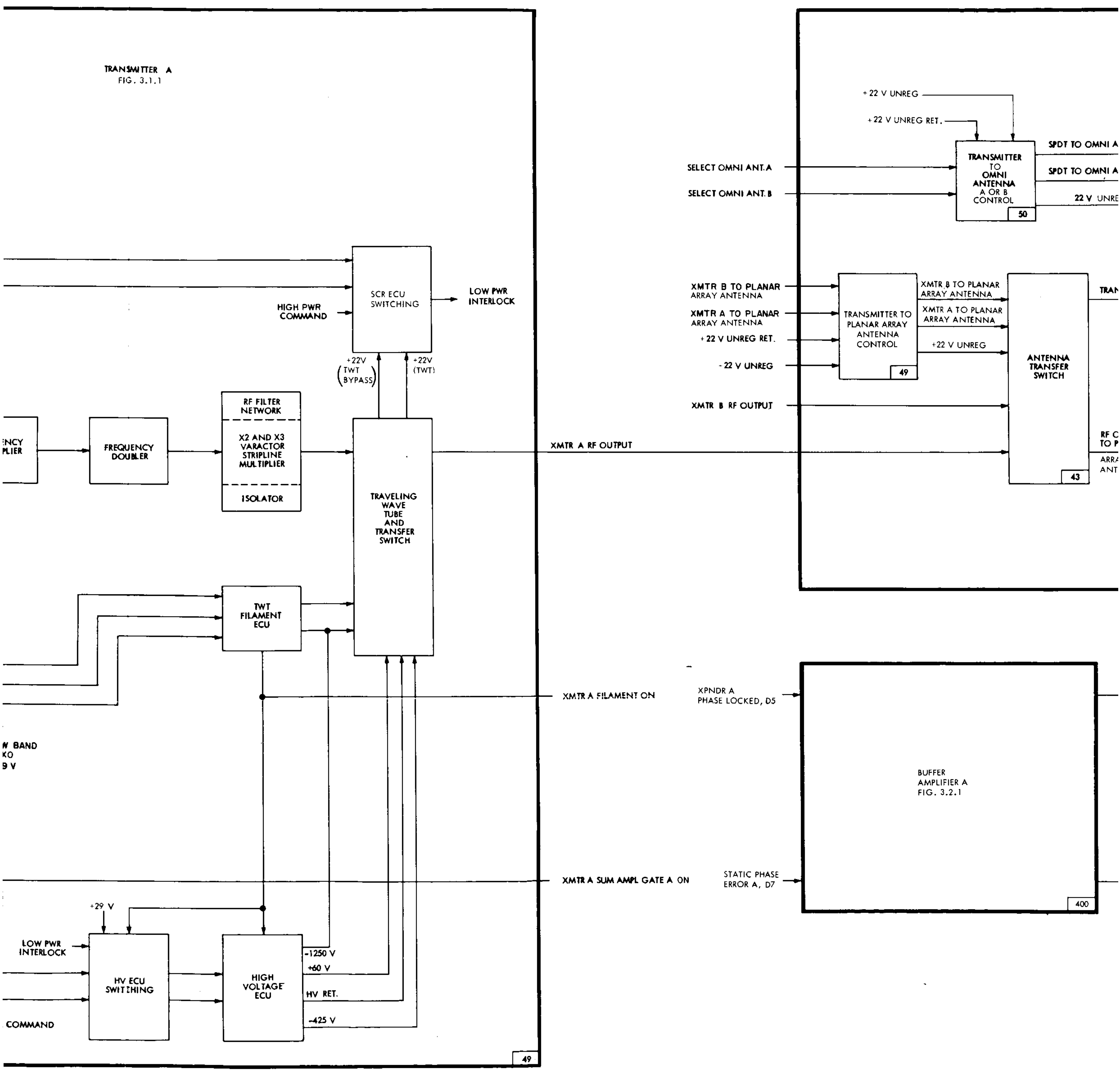
The DIPLEXER permits simultaneous transmission and reception of different frequencies on the same antenna. The transmitter RF output from the DIPLEXER is applied to the STRIPLINE POWER MONITOR. A small portion of the transmitter RF, during high power transmission only, is rectified and filtered by the STRIPLINE POWER MONITOR and supplied to ESP Voltage Measurement Commutation that is transmitted to ground control as an indication of transmitter operation. The remaining portion of the transmitter RF output is applied through the STRIPLINE POWER MONITOR to OMNI ANTENNA B and radiated to ground control.

The "Receiver A RF" or "Receiver B RF" from OMNI ANTENNA A or OMNI ANTENNA B is a 2119-mc signal phase modulated by a command subcarrier, which is in turn frequency modulated by command information. The purpose of this signal is to provide the Surveyor system with command information via RF from ground control. This signal, as received by the omnidirectional antennas, is applied through a STRIPLINE POWER MONITOR to either DIPLEXER A or DIPLEXER B. The RF output of DIPLEXER A or DIPLEXER B is applied through the LOW PASS FILTER to the CAVITY MIXER in Receiver/Transponder A or Receiver/Transponder B. The DIPLEXER normally provides 60 db of isolation between the transmitter and receiver at the transmitted frequency of 2295-mc. When the TWT is switched into the output of the transmitter the third harmonic of the TWT output is not sufficiently attenuated by the DIPLEXER. The added isolation is provided by the LOW PASS FILTER, which attenuates the third harmonic of TWT output by 30 db without attenuating the "Receiver RF".



RECEIVER/TRANSPON
FIG. 3.2.1


3
4
5
RECEIVER A AGC, D9
RECEIVER +15V
SECOND
(LIMITED IF)
COMMAND
SUBCARRIER
SECOND
IF
MIXER
9.6
MC
SECOND
IF
AMPL
9.6 MC
FIRST
DISCRIMINATOR
SECOND
DISCRIMINATOR
RECEIVER A
COMMAND OUTPUT
AGC
RECEIVER A AFC, D16
XPNDR + 15V
STATIC PHASE ERROR A, D7
RECEIVER
+15 V
ECU
DC TO DC
CONVERTER)
RECEIVER A +29 V
RECEIVER A −12 V
XPNDR A PHASE
LOCKED, D5
RECEIVER VCXO (RF) AND PHASE LOCK (DC)
RECEIVER +15 V
R A
51
XFR SW A HIGH PWR
XFR SW A LOW PWR
NARROW BAND
VCXO
+29 V
XMTR +29 V
XMTR
+29 V
WIDEBAND FM XMTR A
TV INPUT WIDE/NARROW BAND
WIDE BAND
VCXO PM
AND FM
MODULATOR
FREQU
MULT
NARROW BAND
VCXO
+29V
NARROW
BAND VCXO
PM AND FM
MODULATOR
PHASE MODULATION XMTR A
XMTR A FIL PWR ON
XMTR A FIL PWR OFF
+29V
REG NONESS
NARROW BAND VCXO OFF
NARROW BAND VCXO ON
NARROW
BAND VCXO
CONTROL
NARRO
VC
+2
XMTR LOW PWR OFF
+ 29 V REG XMTR LOW RIPPLE
XMTR A LOW PWR ON
+ 29 V REG XMTR LOW RIPPLE RET
XMTR
LOW PWR
CONTROL
XMTR +29 V
XMTR HIGH VOLT OFF
XMTR A HIGH VOLT ON
XMTR HIGH VOLTAGE ON (CENTAUR)
XMTR A AND B HIGH VOLTAGE ON
XMTR A AND B HIGH VOLTAGE OFF
HIGH
POWER
NETWORK
HV ON
HV OFF
HIGH PW


TRANSMITTER A
FIG. 3.1.1
SCR ECU SWITCHING
HIGH PWR COMMAND
LOW PWR INTERLOCK
+22V (TWT BYPASS)
+22V (TWT)
RF FILTER NETWORK
X2 AND X3 VARACTOR STRIPLINE MULTIPLIER
ISOLATOR
FREQUENCY DOUBLER
TRAVELING WAVE TUBE AND TRANSFER SWITCH
XMTR A RF OUTPUT
TWT FILAMENT ECU
XMTR A FILAMENT ON
XMTR A SUM AMPL GATE A ON
+29 V
LOW PWR INTERLOCK
HV ECU SWITCHING
HIGH VOLTAGE ECU
-1250 V
+60 V
HV RET.
-425 V
COMMAND
49
+22 V UNREG
+22 V UNREG RET.
SELECT OMNI ANT. A
SELECT OMNI ANT. B
TRANSMITTER TO OMNI ANTENNA A OR B CONTROL
50
SPDT TO OMNI A
22 V
XMTR B TO PLANAR ARRAY ANTENNA
XMTR A TO PLANAR ARRAY ANTENNA
+22 V UNREG RET.
-22 V UNREG
TRANSMITTER TO PLANAR ARRAY ANTENNA CONTROL
49
+22 V UNREG
ANTENNA TRANSFER SWITCH
XMTR B RF OUTPUT
43
XPNDR A PHASE LOCKED, D5
BUFFER AMPLIFIER A
FIG. 3.2.1
STATIC PHASE ERROR A, D7
400

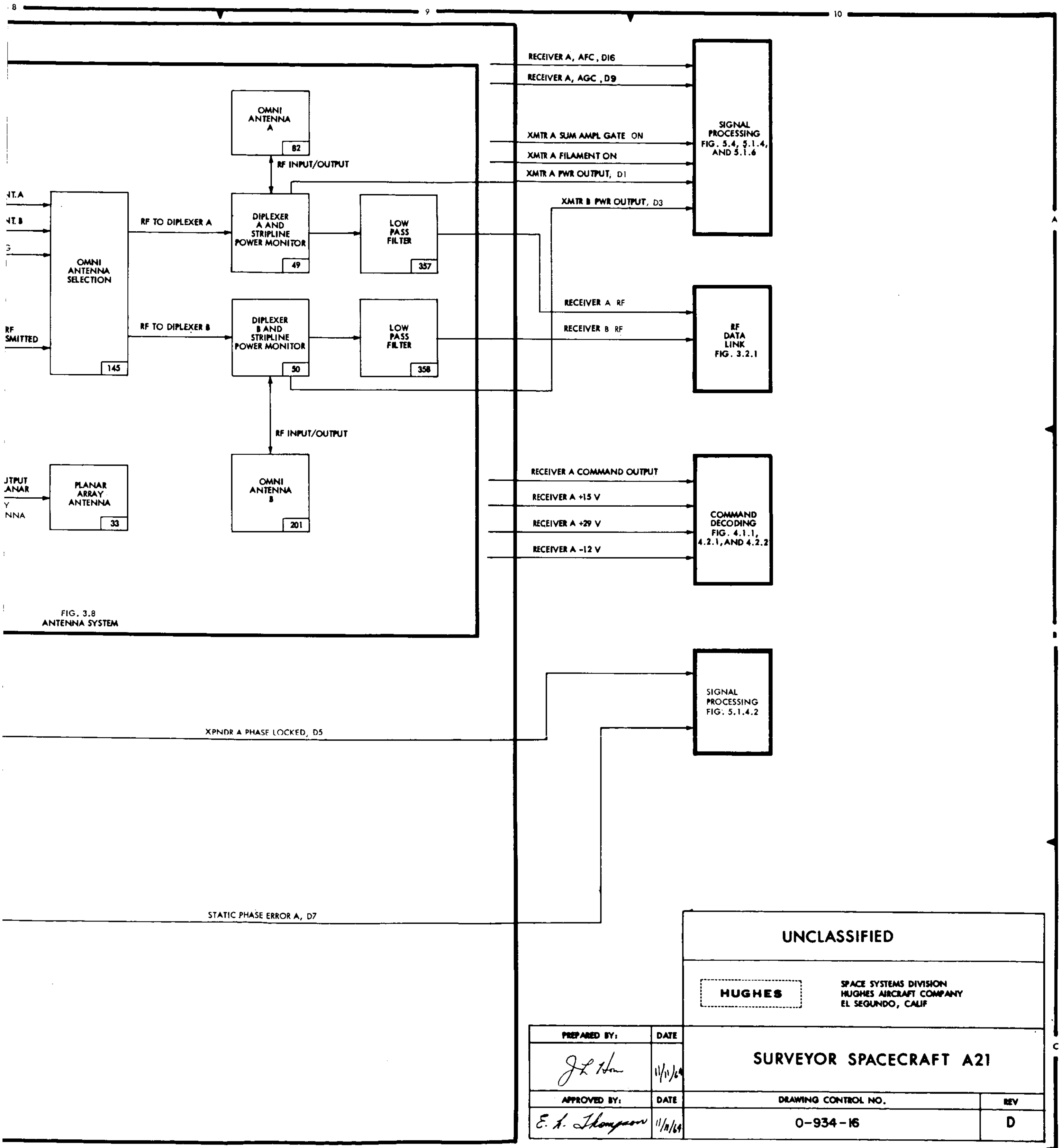


Figure 3.0. RF Data Link, Functional Block Diagram

SECTION IV

COMMAND DECODING

This section contains functional block diagram and general functional theory for the COMMAND DECODING FUNCTION. Functional schematic diagrams and more detailed functional theory are contained in Section IV of Volume II of this publication. A command Assignment table is also contained in Section IV of Volume II.

4.1 COMMAND DECODING FUNCTION (Fig. 4.0)

Prepared by ____________________ date ______________

Approved by ____________________ date ______________

4.2 GENERAL.

The COMMAND DECODING FUNCTION consists of solid state circuits located in the CENTRAL COMMAND DECODER, ENGINEERING MECHANISMS AUXILIARY, TELEVISION AUXILIARY, and the FLIGHT CONTROL SENSOR GROUP.

The purpose of the COMMAND DECODING FUNCTION is to select receiver/decoder combinations, check each command for correct address and command complements, and supply commands to specific subsystems within the spacecraft.

4.3 OPERATIONAL REQUIREMENTS.

The COMMAND DECODING FUNCTION is operational when "+29 v ESS" is available from POWER MANAGEMENT and either spacecraft Receiver is operating.

4.4 OPERATIONAL THEORY.

Receiver Decoder Selector

The purpose of the Receiver Decoder Selector (RDS) is to select one of four possible combinations of Receivers and Central Command Decoders (CCD). This assures proper operation of the spacecraft if one Receiver and one CCD becomes inoperable.

The RDS is activated when either Receiver ECU is operating and its outputs are available.

Either Receiver A or B command output is applied to its associated SCHMITT TRIGGER through a 0.5 SEC ON/OFF DELAY causing the input half of the SCHMITT TRIGGER to be near cutoff giving the "Receiver A On" or "Receiver B On" output. The 0.5 SEC ON/OFF DELAY insures that the SCHMITT TRIGGER remains in the same state between pulses. The "Receiver A On" or Receiver B On" signal is applied through an OR gate to the INDEX AMPLIFIER where it is amplified, inverted, and applied to the ECU DRIVERS as the "Index" signal. The "Index" is combined with the output of DECODER SELECT FF2. This combination selects either Central Command Decoder A or Central Command Decoder B. The "Index" also enables the "Boost Reg On" signal for the boost regulation circuitry in the POWER MANAGEMENT FUNCTION.

If either Receiver A or B command output should be interrupted for more than 0.5 sec, the output half of its associated SCHMITT TRIGGER will conduct.

This generates the "Receiver A Off" or "Receiver B Off" signal at the output of the DIFFERENTIATOR. This signal is applied through the COUNTER DRIVER CIRCUIT to RECEIVER SELECT FF1 causing it to select the redundant Receiver. The $\overline{Q1}$ output of FF1 causes DECODER SELECT FF2 to select the redundant Decoder. The outputs of FF1 and FF2 provide the four different Receiver/Decoder combinations.

4.5 Central Command Decoders.

There are two Central Command Decoders to provide redundancy. The operation of the two is identical so only CENTRAL COMMAND DECODER A (CCDA) will be discussed.

The purpose of the Central Command Decoder is to accept earth-transmitted command messages from the spacecraft receivers; generate sync, timing, and control signals from each command; check each command for correct address and command complement; and provide digital signals to the Subsystem Decoders.

CCDA is operational when "+29 v ESS" is available from POWER MANAGEMENT and the "Decoder A On" signal is available from the Receiver Decoder Selector.

The "Decoder A On" is a turn-on signal applied to the ECU A DC TO DC CONVERTER, that enables the generation of the "CCDA Voltage". This signal is the source of other signals after it has been processed by the following circuits:

1. NEGATIVE PULSE ONE SHOT - Processed to give "Flip Flop Initial Set" (FFIS).

2. BIAS VOLTAGE - Processed to give "Anti-Noise Biase Voltage" (ANBV) and "Command Enable Bias Voltage (CEBV).

3. SWITCHES - Processed to give "Shift Enable A1", Address or Command Enable A2", "Quantitative Transfer A3", Address Enable A4", "Message Enable A5", "SSD Turn-off A6", "Message Reject A7" and "Command Interlock A16".

The Receiver Command outputs, A and B, are applied to AND gates in the WORD SYNC & PULSE SHAPING CIRCUITS along with the outputs Q1 and $\overline{Q1}$ from RECEIVER SELECT FF1 in the Receiver Decoder Selector. The output from one of the two gates (depending on which Receiver has been selected) is processed to give the WORD SYNC & PULSE SHAPING CIRCUITS outputs. Two outputs from the WORD SYNC & PULSE SHAPING CIRCUITS (PS and $\overline{PS}$) are applied to the CLOCK PULSE CIRCUITS and generate the "Clock Pulse, CP" and the "Quantitative Transfer Clock Pulse, QTCP". QTCP is applied to the Digital Programmer shift register in the FLIGHT CONTROL FUNCTION and causes it to shift. CP and other commands are applied to the DIGIT COUNTER along with the "Word Sync, WS" output of the WORD SYNC & SHAPING CIRCUITS and to the WORD COUNTER along with the "Word Sync Complement, $\overline{WS}$". These combinations control the generation of the signals listed under SWITCHES on page 4-3. CP is also supplied to the SHIFT REGISTER along with "Shift Enable A1", "Anti-Noise Bias Voltage, ANBV", PS and $\overline{PS}$.

The SHIFT REGISTER receives $\overline{PS}$ and PS respectively. $\overline{PS}$ is shifted to the COMPLEMENT CHECK GATING CIRCUIT and if it checks, PS is shifted to the COMMAND INTERFACE AMPS, processed into signals A11 thru A15, and supplied to the Subsystem Decoders. When a quantitative command is received, complement checking does not occur and the quantitative command address is shifted through the QUANTITATIVE & INTERLOCK GATES to the WORD COUNTER where it is processed to generate "Quantitative Transfer A3". This signal is applied to the Digital Programmer shift register in the FLIGHT CONTROL FUNCTION to be processed. When an interlock command is received it is processed similar to a direct command except that signal CI (generated at the QUANTITATIVE & INTERLOCK GATES) is applied to the COMMAND INTERLOCK CONTROL. Signals FFIS, CI, and outputs from the DIGIT COUNTER and WORD COUNTER generate "Command Interlock A16, which permits the spacecraft to execute irreversible commands.

4.6 Subsystem Decoders

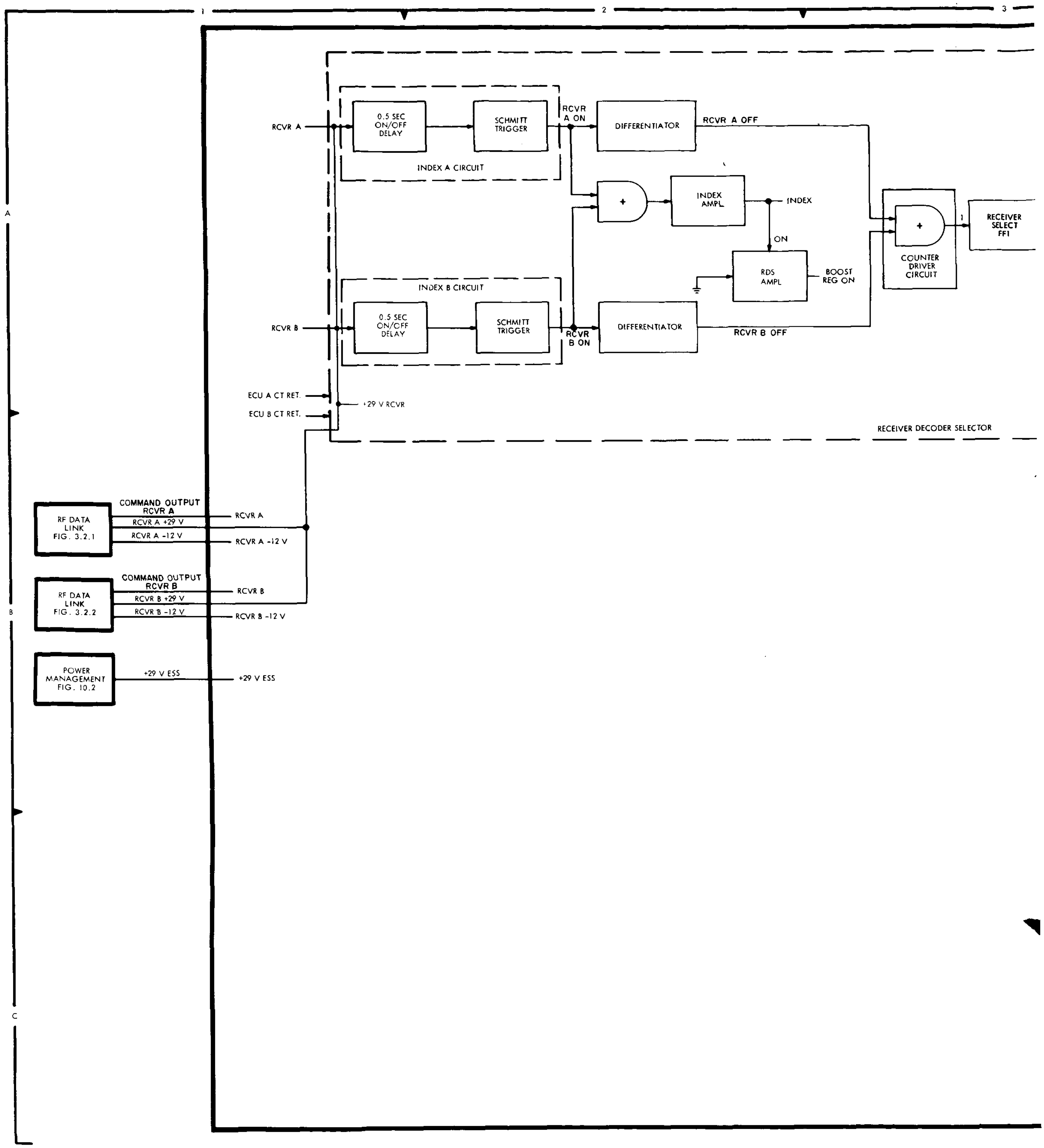
The purpose of the Subsystem Decoders is to supply decoded digital information from either Central Command Decoder to specific subsystems.

Subsystem Decoders 01 thru 05 operate when "+29 v ESS" is available, Subsystem Decoders 06 and 11 operate when "+29 v NON-ESS" is available, and Subsystem Decoder 07 operates when "+29 v Flight Control" is available.

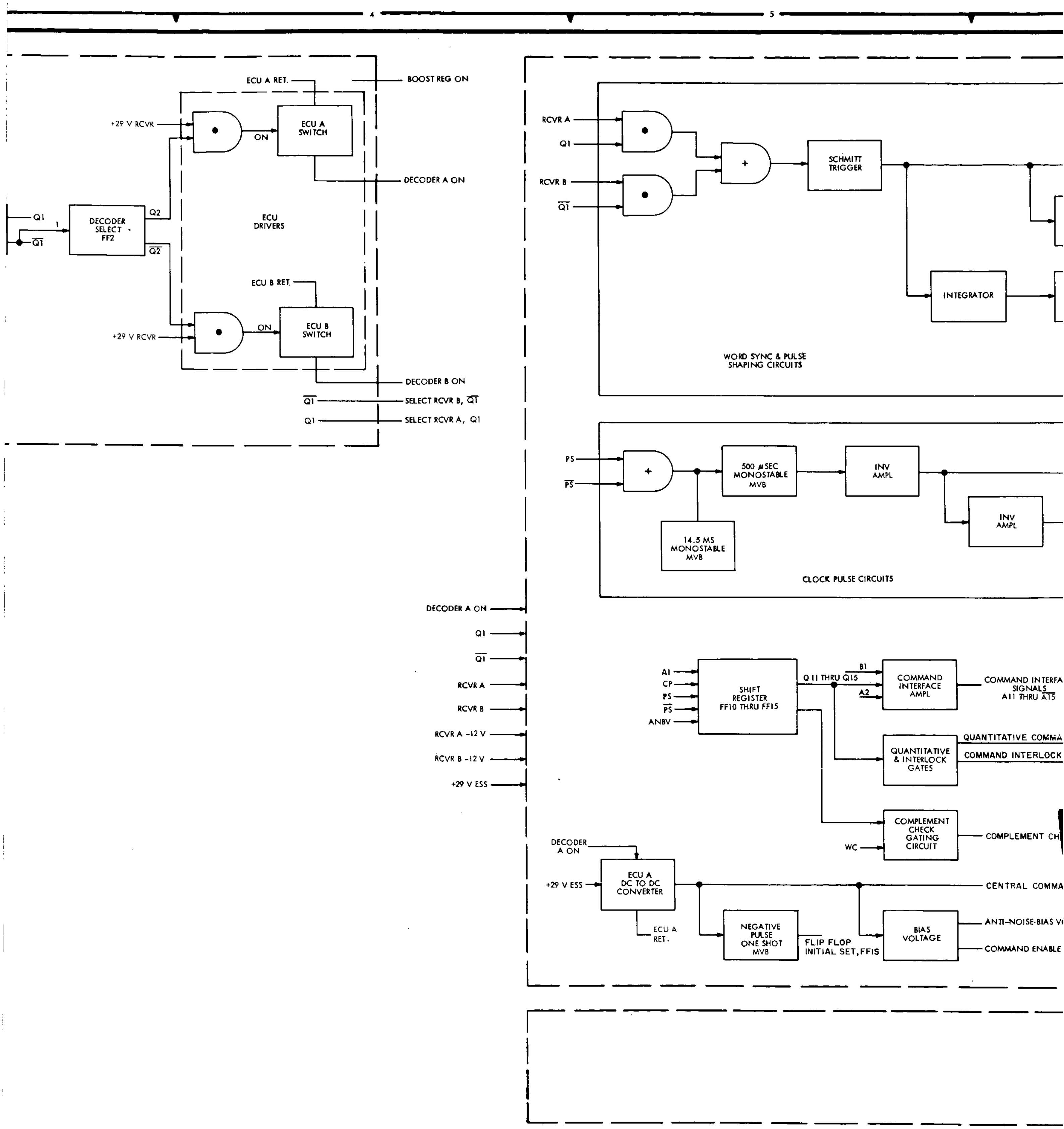
The eight Subsystem Decoders (SD) are identical. The "Address Enable A4" and the proper address result in an output from the address gate. The address gate inputs are supplied from five COMMAND INTERFACE AMPS outputs (selected from A11 thru A15) which will be high when the SD is selected. The resulting output sets the output of two redundant LATCHES to the high state. The high state, combined with A5, turns on SWITCHES that apply power to the decoding GATE MATRIX. The command is read into the GATE MATRIX, decoded and supplied to specific subsystems within the spacecraft.

An irreversible command, such as squib ignition, must be preceded by "Command Interlock A16". This signal is sent from the CCD by an earth command.

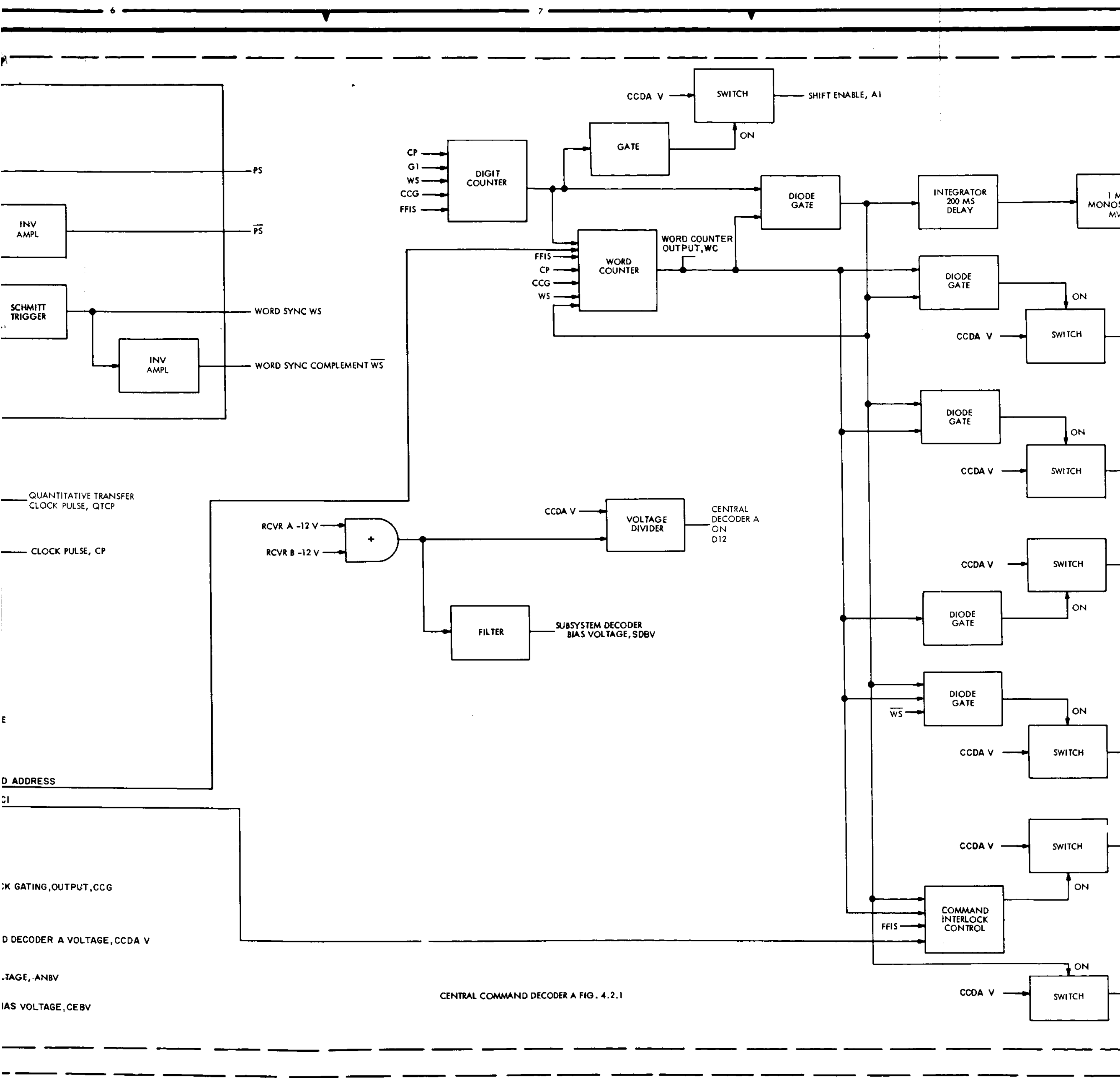
The SD remains on until A6 is applied to the LATCHES, resetting them and causing the power switches to turn off.



RCVR A
0.5 SEC ON/OFF DELAY
SCHMITT TRIGGER
RCVR A ON
DIFFERENTIATOR
RCVR A OFF
INDEX A CIRCUIT
+
INDEX AMPL
INDEX
ON
RDS AMPL
BOOST REG ON
+
COUNTER DRIVER CIRCUIT
RECEIVER SELECT FFI
INDEX B CIRCUIT
RCVR B
0.5 SEC ON/OFF DELAY
SCHMITT TRIGGER
RCVR B ON
DIFFERENTIATOR
RCVR B OFF
ECU A CT RET.
ECU B CT RET.
+29 V RCVR
RECEIVER DECODER SELECTOR
RF DATA LINK FIG. 3.2.1
COMMAND OUTPUT RCVR A
RCVR A +29 V
RCVR A -12 V
RCVR A
RCVR A -12 V
RF DATA LINK FIG. 3.2.2
COMMAND OUTPUT RCVR B
RCVR B +29 V
RCVR B -12 V
RCVR B
RCVR B -12 V
POWER MANAGEMENT FIG. 10.2
+29 V ESS
+29 V ESS

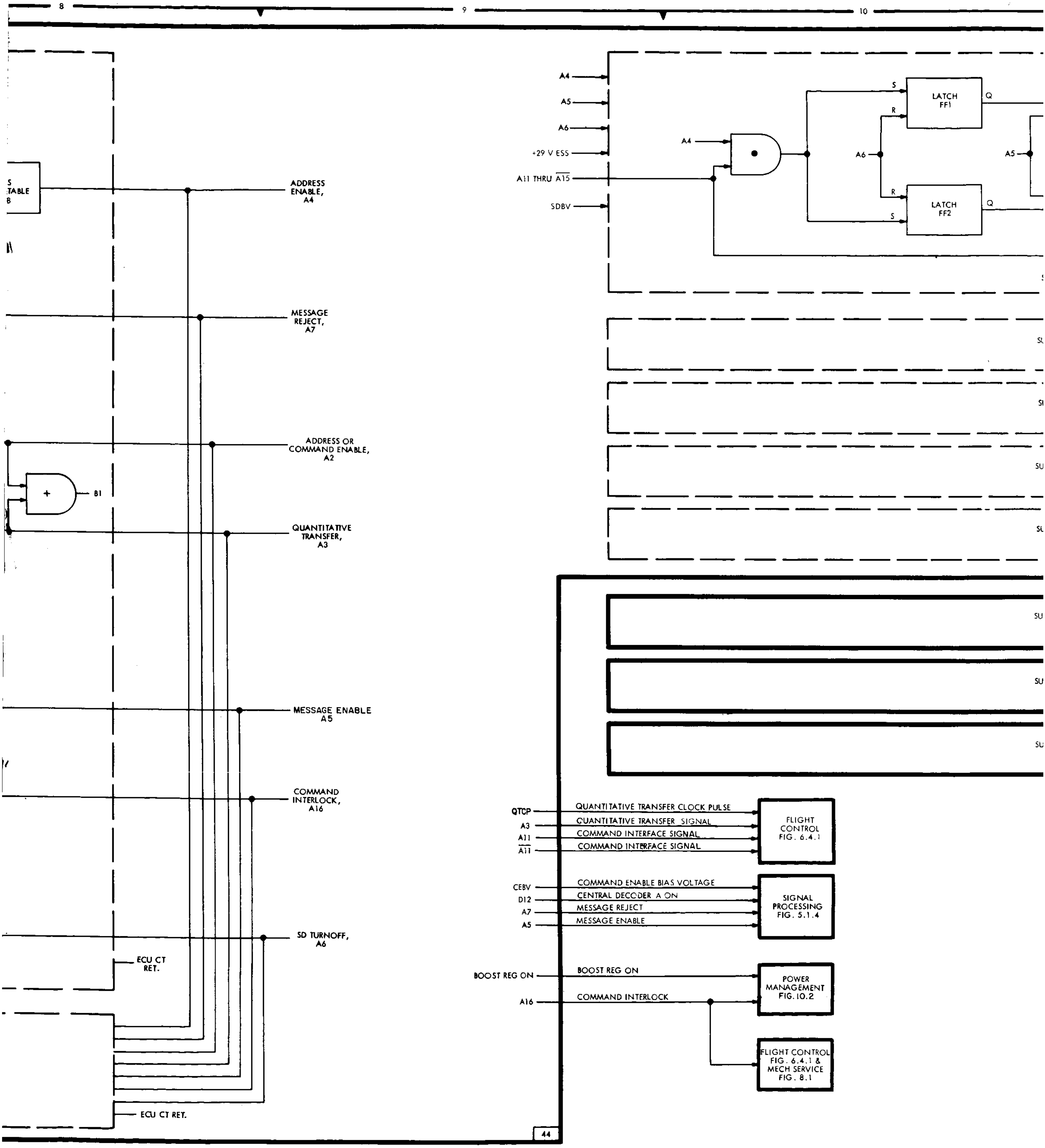


ECU A RET.
BOOST REG ON
+29 V RCVR
ON
ECU A SWITCH
DECODER A ON
Q1
DECODER SELECT FF2
Q2
Q̄2
ECU DRIVERS
ECU B RET.
+29 V RCVR
ON
ECU B SWITCH
DECODER B ON
Q̄1
SELECT RCVR B, Q̄1
Q1
SELECT RCVR A, Q1
RCVR A
Q1
RCVR B
Q̄1
SCHMITT TRIGGER
INTEGRATOR
WORD SYNC & PULSE SHAPING CIRCUITS
PS
P̄S
500 μSEC MONOSTABLE MVB
INV AMPL
INV AMPL
14.5 MS MONOSTABLE MVB
CLOCK PULSE CIRCUITS
DECODER A ON
Q1
Q̄1
RCVR A
RCVR B
RCVR A -12 V
RCVR B -12 V
+29 V ESS
A1
CP
PS
P̄S
ANBV
SHIFT REGISTER FF10 THRU FF15
Q 11 THRU Q15
B1
A2
COMMAND INTERFACE AMPL
QUANTITATIVE & INTERLOCK GATES
QUANTITATIVE COMMA
COMMAND INTERLOCK
COMPLEMENT CHECK GATING CIRCUIT
WC
COMPLEMENT CH
DECODER A ON
+29 V ESS
ECU A DC TO DC CONVERTER
ECU A RET.
CENTRAL COMMA
NEGATIVE PULSE ONE SHOT MVB
FLIP FLOP INITIAL SET, FF1S
BIAS VOLTAGE
ANTI-NOISE-BIAS VO
COMMAND ENABLE



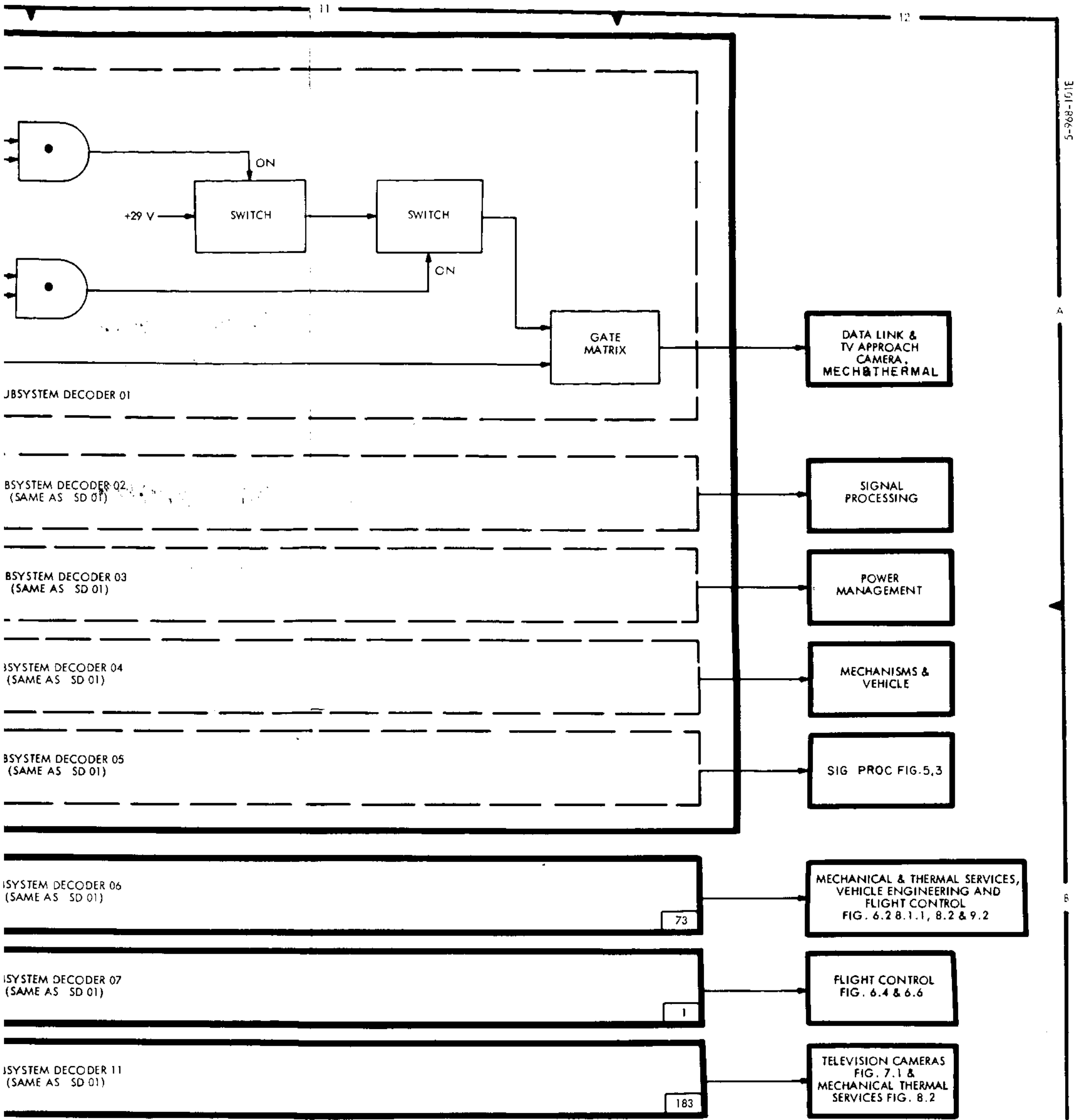
CENTRAL COMMAND DECODER A FIG. 4.2.1

CENTRAL COMMAND DECODER B FIG. 4.2.2
(IDENTICAL TO CENTRAL COMMAND DECODER A)



8
9
10
S
TABLE
B
ADDRESS ENABLE, A4
MESSAGE REJECT, A7
ADDRESS OR COMMAND ENABLE, A2
B1
QUANTITATIVE TRANSFER, A3
MESSAGE ENABLE A5
COMMAND INTERLOCK, A16
SD TURNOFF, A6
ECU CT RET.
ECU CT RET.
A4
A5
A6
+29 V ESS
A11 THRU $\overline{A15}$
SDBV
LATCH FF1
LATCH FF2
S
R
Q
QTCP
QUANTITATIVE TRANSFER CLOCK PULSE
A3
QUANTITATIVE TRANSFER SIGNAL
A11
COMMAND INTERFACE SIGNAL
$\overline{A11}$
COMMAND INTERFACE SIGNAL
FLIGHT CONTROL FIG. 6.4.1
CEBV
COMMAND ENABLE BIAS VOLTAGE
D12
CENTRAL DECODER A ON
A7
MESSAGE REJECT
A5
MESSAGE ENABLE
SIGNAL PROCESSING FIG. 5.1.4
BOOST REG ON
BOOST REG ON
POWER MANAGEMENT FIG. 10.2
A16
COMMAND INTERLOCK
FLIGHT CONTROL FIG. 6.4.1 & MECH SERVICE FIG. 8.1
44

Changed 15 A



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HUGHES — SPACE SYSTEMS DIVISION, HUGHES AIRCRAFT COMPANY, EL SEGUNDO, CALIF.

PREPARED BY:	DATE	SURVEYOR SPACECRAFT A21	
R.J. McCulloch	11/29/63		
APPROVED BY:	DATE	DRAWING CONTROL NO.	REV
J.R. Stine	12/6/63	5-968-101	E

Figure 4.0. Command Decoding, Functional Block Diagram

SECTION V

SIGNAL PROCESSING

This section contains functional block diagrams and general functional theory for the SIGNAL PROCESSING FUNCTION. Functional schematic diagrams and functional theory are included in Section V of Volume II.

5.1 SIGNAL PROCESSING FUNCTION. (Fig. 5.0)

Prepared by S. S. Sanford Date 24 Feb '64

Approved by R. G. Pietropaolo Date 11 Mar '64

5.2 GENERAL.

The equipment items implementing the SIGNAL PROCESSING FUNCTION are the Flight Control Sensor Group (FCSG), Central Signal Processor (CSP), Engineering Signal Processor (ESP), Television Auxiliary (TVA), Signal Processing Auxiliary (SPA), Low Data Rate Auxiliary (LDRA), and Auxiliary Engineering Signal Processor (AESP). Only certain portions of the Flight Control Sensor Group and the Television Auxiliary are used in the SIGNAL PROCESSING FUNCTION. These portions are located on component board number 8 of the Flight Control Sensor Group and component board number 183A1 of the Television Auxiliary.

The purpose of the SIGNAL PROCESSING FUNCTION is to prepare the data produced by the voltage, current, temperature, and pressure sensors, television cameras, accelerometers, and strain gages for transmission to ground stations. This function does not include transmitter modulation or transmission.

5.3 OPERATIONAL REQUIREMENTS.

The SIGNAL PROCESSING FUNCTION may be operated whenever "29 Volt Regulated Non-essential" power is available, and is controlled by commands which select Commutator Mode, Data Rate, Analog to Digital Converter, Subcarrier Oscillators and Summing Amplifiers. "29 Volt Regulated Non-essential" power is ordinarily available at all times. However, if a malfunction develops in the Spacecraft that results in only a small amount of power being available for Spacecraft operation, only the most essential functions such as Receivers, Decoders, and Flight Control receive power. Under such conditions, the SIGNAL PROCESSING FUNCTION is rendered inoperative.

5.4 OPERATIONAL THEORY.

5.5 Timing and Logic Rate Signals.

The Analog to Digital Converter (A/D Converter) is the source of all timing and logic rate signals for the SIGNAL PROCESSING FUNCTION.

The CRYSTAL CONTROLLED OSCILLATOR operates at 35.2 kc. This frequency is processed through COUNTDOWN CIRCUITS which successively divide by 4 to provide an output of 8400 cps. This output is fed to BIT RATE SELECTION, which produces bit rates of 4400, 1100, and 550 bps. Any of these data rates may be selected by the appropriate "Data Rate Select" command. The 550-bps signal is applied to the Low Data Rate Auxiliary (LDRA), which contains countdown flip-flops to provide bit rates of 550, 137.5, or 17.1825 bps upon "Low Data Rate Select" command. The low bit rate selected is fed back into the A/D Converter BIT RATE SELECTION, and on into CLOCK PULSE SHAPING & DELAY. A Clock Pulse (CP) occurs for each cycle of the BIT RATE SELECTION flip-flop whose output is selected to establish the data rate. CP1 occurs 30 usec after CP, and CP2 occurs 10 usec after CP1 or 40 usec after CP. These delays are necessary to compensate for inherent signal delays within the system. CP is applied to the input of a four flip-flop 11-count circuit (DIGIT TIME SIGNAL GENERATION). This circuit provides two sets of count signals. The first set is T301 thru T311, and the second is A302 thru A311 (ATS). The ATS series corresponds in time relationship to T302 thru T311, but is of opposite polarity. A302 thru A311 are the timing signals for the BINARY VOLTAGE WEIGHTING SWITCHES. T301 thru T310 are Digit Time Signals (DTS) used for Digital Word Assembly (para 5.10). T301 is the Commutator Advance Signal (CAS) (para 5.6) used to step the commutators.

5.6 Commutator Gate Select.

The ESP gate select and the AESP gate select circuits are similar in their operation and circuitry. The purpose of the gate select circuitry is to provide commutator count and switch group selection. Commutator count is accomplished by applying the "Commutator Advance Signal" (CAS) to the input of a four flip-flop 10-count circuit. This is the vertical or "Y" count on the commutator matrix format. The horizontal or "X" count is accomplished in the same fashion as the "Y" count except that "Y1" going negative ("GY510" in the ESP and "GY110" in the AESP) serves as the CAS. The ESP counts from 1 to 10 in the "X" direction, and the AESP counts from 1 to 12. The result is that the "Y" circuits will count from 1 to 10 with the "X" counter in the "X1" position. When the "Y" count returns to "Y1," the "X" counter will step to "X2," and the "Y" count will step from 1 thru 10 and so forth. This provides a 100 word count capacity for the ESP and a 120 word count capacity for the AESP.

For each combination of "X" and "Y" (each word) there are two information inputs to the AESP and either three or four information inputs to the ESP. These inputs are divided into groups relating to the conditions requiring their transmission to ground stations. These groups are selected by the mode select commands and are used to provide commutator flexibility and to save power. Each mode selects one or more groups, and a given group may be included in several mode selections. To provide synchronization for ground station decommutators, "sync" and "sync complement" signals are generated at the start of each "frame" (one complete counting cycle). The "sync" and "sync complement" signals occur as words 00 and 0 in the ESP and as words 118, 119, and 120 in the AESP.

REJECT/ENABLE DIGITAL PROCESSING occurs in both the ESP and the AESP. These are signals either in a high or a low state and are telemetered to DSIF stations to indicate whether or not the preceding command was properly received. This information is commutated at "X1 and Y10" in the ESP and at "X8 and Y3" and "X12 and Y1" in the AESP. It is also telemetered via Subcarrier Oscillator in the ESP.

5.7 Voltage Measurement Commutation.

Voltage Measurement Commutation is accomplished by monitoring a voltage source directly or across a portion of a voltage divider network. This voltage is commutated directly onto a common output by using the "X," "Y," and "group select" signals to turn on a switch. Operation of Voltage Measurement Commutation in the ESP and the AESP is identical.

5.8 Current Measurement Commutation.

Current in a circuit is measured as a voltage drop across a low value resistor placed in series with the voltage source and the load. This voltage is placed across the input of a commutator switch and is then amplified in a DIFFERENTIAL AMPLIFIER by a factor of 50 and switched onto the commutator common line. "X," "Y," and "group select" signals are used to operate the commutator switches. These signals operate three switches for each current measurement; one in each side of the differential input, and one on the amplifier output.

Commutated voltage, temperature, and current commutated signals are combined on a common commutator line (one each in the ESP and the AESP) and sent to the CSP Master Switch via a Bootstrap Unloader (BSU). A BSU is used on the commutator output line to equalize line impedance and minimize data distortion. Current Measurement Commutation in the ESP and the AESP is identical.

5.9 Temperature Measurement Commutation.

Temperature measurement commutation is accomplished by passing a constant current through a resistor whose resistance is a known function of temperature and measuring the voltage drop across it. This voltage is then commutated and sent on to the Analog to Digital Converter. The majority of the temperature sensing resistors have a resistance of 0 to 1000 ohms. For these, a Constant Current of 5 ma is supplied by BASIC ACCURACY CONSTANT CURRENT GENERATORS #1 and #2. This provides a temperature indication of 0 to 5 v when passed through the temperature sensor. For a few special applications, a higher accuracy temperature indication is required. For these, a Constant Current of approximately 2.5 ma is supplied to high accuracy temperature measurement resistors whose resistance is 0 to 2000 ohms. This constant current is supplied by a HIGH ACCURACY CONSTANT CURRENT GENERATOR which provides greater accuracy by adjusting for 2.5 ma on the sensor return. Temperature measurement commutation uses the "X," "Y," and "group select" signals generated in Commutator Gate Select to commutate the temperature measurement voltages on a time-shared basis. Each switch used for this purpose is a double switch. The first part switches constant current on to the sensing resistor one word time before a temperature is to be sampled, to allow stabilization of circuit time constants. It remains on for the next word time while the second part of the switch closes causing the voltage generated across the sensor to be commutated onto the common output line for one word time. Both switches then turn off. Temperature measurement commutation requires two word times per measurement, and information is commutated onto the common line for only the second of these. Therefore, temperature information is commutated on alternate, even-numbered words, allowing other data (voltage, current, and digital words) to be commutated on the words between them. Operation of Temperature Measurement Commutation in the ESP and the AESP is identical.

5.10 Digital Word Assembly.

Certain data to be telemetered is in the form of on-off (digital) indications rather than varying d-c (analog) signals. For this type of data, each word is broken into 11 digits by a Digit Time Signal (DTS) which is generated in the Analog to Digital Converter. The first ten of these digits are used in conjunction with Digital Gates (DG) to sample 10 ON-OFF indications in each word time. The DG's are generated by "X," "Y," and "group select" signals. The Digital Word Assembly circuitry located in the Flight Control Unit receives DG's from the ESP or AESP Digital Word Assembly. Digital Words 1, 2, 3, 4, and 9 are assembled in the Flight Control Unit, Digital Words 5 thru 8 are assembled in the ESP; and Digital Words 10 thru 13 are assembled in the AESP. The AESP also contains gating circuitry to indicate to the Analog to Digital Converter whether analog or digital information is being sampled.

5.11 Television Auxiliary.

The Television Auxiliary (TVA) contains an ECU which operates similar to that in the ESP (see para 5.16). The TVA contains commutator gating circuitry which counts four steps in the "X" and "Y" directions giving a sixteen word count. No group select gating is used. The TVA contains gating circuits to enable its output to be accepted by the Analog to Digital Converter. It is used to commutate data other than video produced by the TVA such as focus, filter position, and exposure mode. A BSU is used on the commutator output line for impedance equalization as in the ESP and AESP. (See para 5.8.)

5.12 Analog to Digital Conversion.

Input of commutated analog data to the Analog to Digital Converter (A/D Converter) is controlled by a MASTER SWITCH. This function ensures that the output of only one of the commutators will be allowed to enter the analog to digital conversion circuits. Commands issued at ground stations determine which commutator output will be accepted. Analog to Digital conversion is performed in order to transmit data to ground stations in a simple and reliable manner. Digital coding provides a simple method of self checking for accuracy of transmission. The A/D Converter contains an ECU whose operation is similar to that of the ESP ECU. (See para 5.16.) A -5 VOLT REFERENCE SUPPLY is included which provides a voltage source for the nulling operation in the BINARY VOLTAGE WEIGHTER (BVW). A +2 VOLT BIAS SUPPLY is used to "buff" flip-flop and switching inputs so stray noise voltages will not trigger them and cause incorrect data processing.

Actual analog to digital conversion is performed using a successive approximation type analog to digital converter. The analog voltage to be converted (A/D_A), is applied to the input of the BVW network, and a series of approximations is made. Each approximation is one-half its predecessor. A "1" or high state appears at the A/D output (A403) if the approximation is less than or equal to the difference between the input voltage and the preceding approximation. A "0", or low state, appears if the approximation is greater than the difference. A voltage representing the approximation increment is added to the approximation if a "1" output is present. It is not added if a "0" output is present. Feedback signal A400 determines whether or not the approximation increment will be added. The resultant digital output is a 10 digit binary sequence approximating the analog voltage input. This sequence is generated during digit times T301 through T310.

"T311" is used for a parity check bit and provides some confidence that noise is not causing erroneous pulses. The parity bit is high (logical "1" state) if the number of high digits in a word is even and is low (logical "0" state) if the number of high digits is odd. The state of the parity bit is determined by PARITY BIT GENERATOR FLIP-FLOP 311. The output of the BVW is amplified and gated with N311 ("NOT T311") and N302 in an AND circuit and sent through the Readout OR gate to the READOUT AMPLIFIER. This is the digitized analog output. N302 is high at all times except when synchronizing words are generated; N311 is high at all times except when the parity bit is generated.

The outputs of the ESP, AESP, and Flight Control Digital Word Assemblies and the DG's (para 5.10) are each gated in an AND circuit with the digital data gate A503 from the ESP/AESP and sent through the Readout OR gate to the READOUT AMPLIFIER and are the Digital Words output.

The "sync complement" gating signals from the ESP, AESP, and TVA are inputs to an OR gate. If any one signal is present, a "Master Sync Complement" signal, B900, is generated. B900 is inverted and gated with digit time A311 and Parity Flip-Flop output 311 in an AND gate and sent through the Readout OR gate to the READOUT AMPLIFIER. This is the parity indication and is sent at time T311 in every word except "sync" and "sync complement" words. Barker Word generation is accomplished by the Digit Time Signal Flip-Flops. The Barker Word (11100010010) is a calculated series of eleven digits which would be the least likely to occur at random in a binary digital sequence. The Barker Word complement and B900 are used as inputs to an AND gate and sent through the Readout OR gate to the READOUT AMPLIFIER. This is the commutator "sync complement" indication and is readily recognized by the ground decommutator. The Barker Word and the ESP/AESP "sync" signal are used as inputs to an AND gate and sent through the Readout OR gate to the READOUT AMPLIFIER. This is the commutator "sync" indication.

The output of the READOUT AMPLIFIER is used to drive READOUT FLIP-FLOP 307 for digit shaping. It also provides the operating information required by the Parity Bit Generator. The output of the READOUT FLIP-FLOP is amplified and inverted and provides Digit Voltage Weighting feedback signal, A400. It is also sent to the CSP Subcarrier Oscillators and to an Isolation Amplifier. Here, the output of whichever A/D Converter is in operation (A403 or B403) is amplified and sent through CENTAUR INTERFACE to the "blockhouse" and can be monitored before launch and after launch until Centaur separation. "A/D Iso OUT" is also sent to the SPA and LDRA Subcarrier Oscillators.

5.13 ESP Subcarrier Oscillators.

Signals which change too rapidly for accurate analog to digital conversion directly modulate a subcarrier oscillator (SCO). Signals of this type are outputs of gyros, accelerometers, and strain gauges. Four Vehicle Accelerometer signals are used to modulate voltage-sensitive SCO's. The four SCO outputs are summed in a weighted summing amplifier.

There are four data inputs to the Gyro Speed Processing circuits; one each from Roll, Pitch, and Yaw gyros, and one common return. Each of these can be monitored in turn by issuing "Switch Next Gyro Speed Channel" commands. This command is fed into a SCHMITT TRIGGER whose output spike steps a two flip-flop counting circuit. The count signals are used to select the desired Gyro Speed Channel. The selected Gyro Speed signal is then amplified, counted down by a factor of 32, and used to modulate the 5.4-kc GYRO SPEED SCO. Reject/Enable signals (para 5.7) are used to modulate a subcarrier oscillator (SCO). The subcarrier frequency is deviated high for a reject signal and low for an enable signal. This provides a second telemetry channel for this signal. Its purpose is to provide Reject/Enable signals when the commutators are turned off. Reject/Enable and Vehicle Accelerometer SCO's can be turned on or off by sending appropriate SCO ON or OFF commands. Gyro Speed Indication Processing is turned on or off by commanding the GSP ECU on or off. The operation of this ECU is similar to that of the ESP ECU. (See para 5.16.)

The "R/E SCO Out," "Accel SCO Out," and "Gyro SCO" signals are then fed to the Transmitter Summing Amplifiers.

5.14 AESP, CSP, LDRA, & SPA Subcarrier Oscillators.

The AESP processes four accelerometer signal inputs on a time-shared basis. When this data channel is turned on by "Accel On," the STEPPING MULTIVIBRATOR and both the 130-kc and the 150-kc SCO's are turned on. The STEPPING MULTIVIBRATOR selects inputs 5 and 6 alternately with inputs 7 and 8. Inputs 5 and 7 are used to modulate the 130-kc SCO and inputs 6 and 8 are used to modulate the 150-kc SCO. The SCO outputs are weighted, summed and sent to the Transmitter Summing Amplifiers.

The inputs from the Shock Absorber Strain Gages are used to modulate 1.7-kc, 3.0-kc, and 5.4-kc SCO's when this data channel is turned on by "Touchdown Strain Gage Channels On." These SCO outputs are summed and sent to the Transmitter Summing Amplifiers.

"A/D Iso Out" from the A/D Converter (para 5.13) is used to modulate 560 cps and 960 cps SCO's whose outputs are weighted, summed, and sent to the PRE SUMMING AMPLIFIER when either "Coast Phase I SCO On" or "Coast Phase II SCO On" command is given. This channel is used only with the low bit rates and "Low Data Rate SCO Output." "A/D Iso Out" is also used to modulate a 3.9 kc SCO for low modulation index transmission. The output of this SCO is attenuated and sent to the PRE SUMMING AMPLIFIER.

When the A/D Converter is operating, its output (A403 or B403) is gated to the input of a 3.9 kc, 7.35 kc, or 33.0 kc SCO. The output of the SCO selected is sent to the PHASE MODULATION TRANSMITTER A & B SUMMING AMPLIFIERS and FREQUENCY MODULATION TRANSMITTER A & B SUMMING AMPLIFIERS and is the main channel of digital telemetry. The SCO selected depends on the data rate being used.

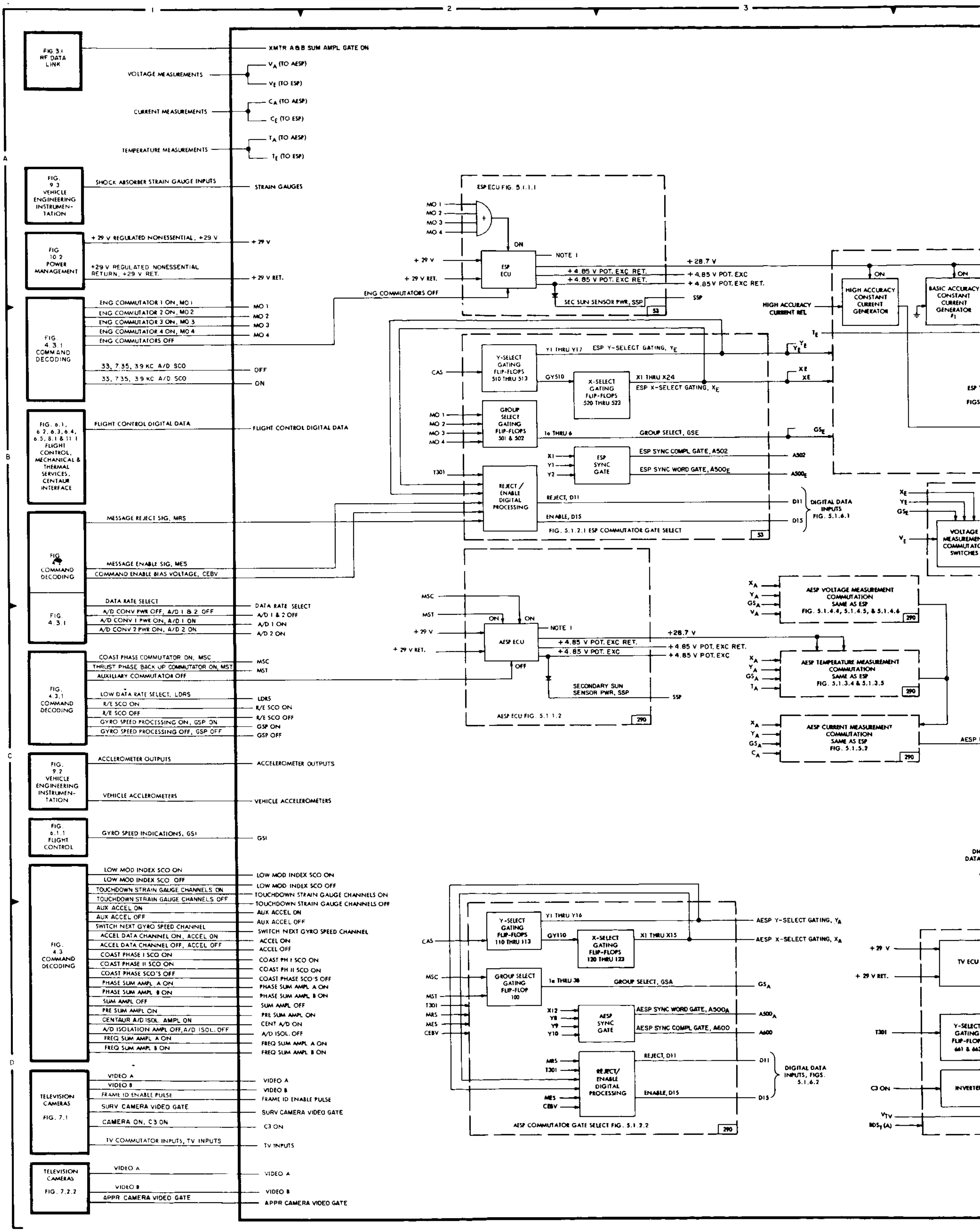
5.15 Summing Amplifiers.

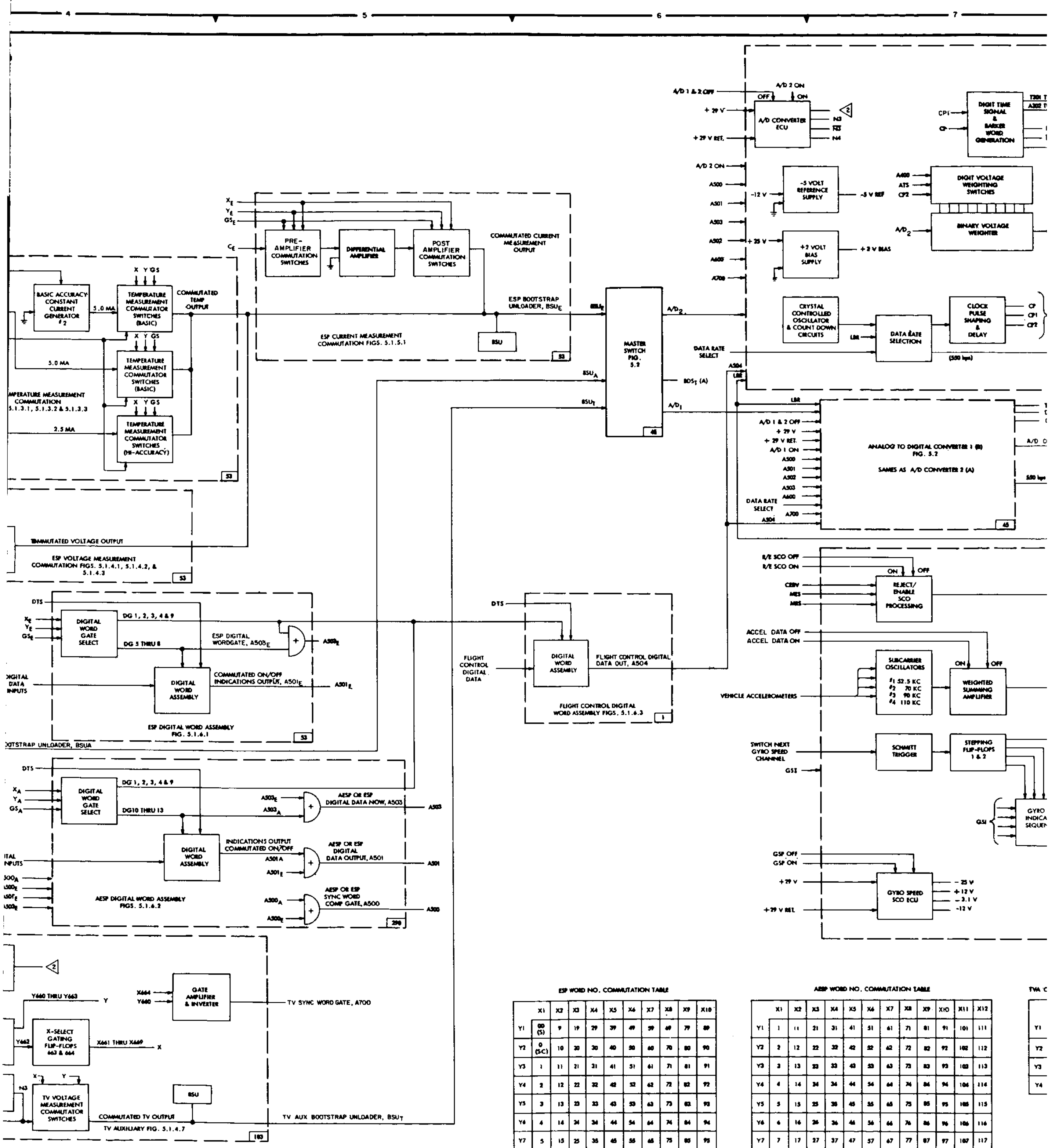
TELEVISION SUMMING AMPLIFIERS A & B each have a video input from television cameras 3 and 4 as well as "Frame ID Enable Pulse" from television camera 3 and "A403" and "B403" from the A/D Converter (para 5.12). When the cameras are scanning the Vidicon Faceplate, the Video is sent to the transmitter. When scanning is finished, "Frame ID Enable Pulse" cuts off the video input and allows the output of the A/D Converter, which is digitizing the output of the TVA, to be transmitted.

The Spacecraft contains two FREQUENCY MODULATION TRANSMITTER SUMMING AMPLIFIERS (A & B) and two PHASE MODULATION TRANSMITTER SUMMING AMPLIFIERS (A & B), any of which may be turned on by command. The "R/E SCO" output, both Vehicle Accelerometer SCO outputs, and the 3.9-kc, 7.35-kc, or 33.0-kc SCO output are summed in the FM Summing Amplifiers for frequency modulation transmission. The "Gyro SCO" output, the 3.9-kc, 7.35-kc, or 33.0-kc SCO output, and the summed output of the Strain Gage SCO, the Low Data Rate SCO, and the Low Modulation Index SCO are summed in the PM Summing Amplifiers for phase modulation transmission.

5.16 Electrical Conversion Units.

Operational Voltages for the Engineering Signal Processor (ESP) and the Auxiliary Engineering Signal Processor (AESP) are provided by an Electrical Conversion Unit (ECU) located in each of these units. The ESP ECU and the AESP ECU are identical except for the number of Mode Select turn-on commands available to them. When "29 Volt Regulated Non-essential" power is available and any of the commutator mode select commands is given, one of the ECU's will be activated. The ESP and the AESP may not be operated simultaneously. The mode select command turns on the ECU which provides operational voltages ranging from +29 to -30 v. The +5 v output of each ECU provides excitation for various sensors in the Spacecraft. It is also used to provide Secondary Sun Sensor Power if the Flight Control power should fail. The ECU's can be turned off by sending a commutator turn-off command.





ESP WORD NO. COMMUTATION TABLE

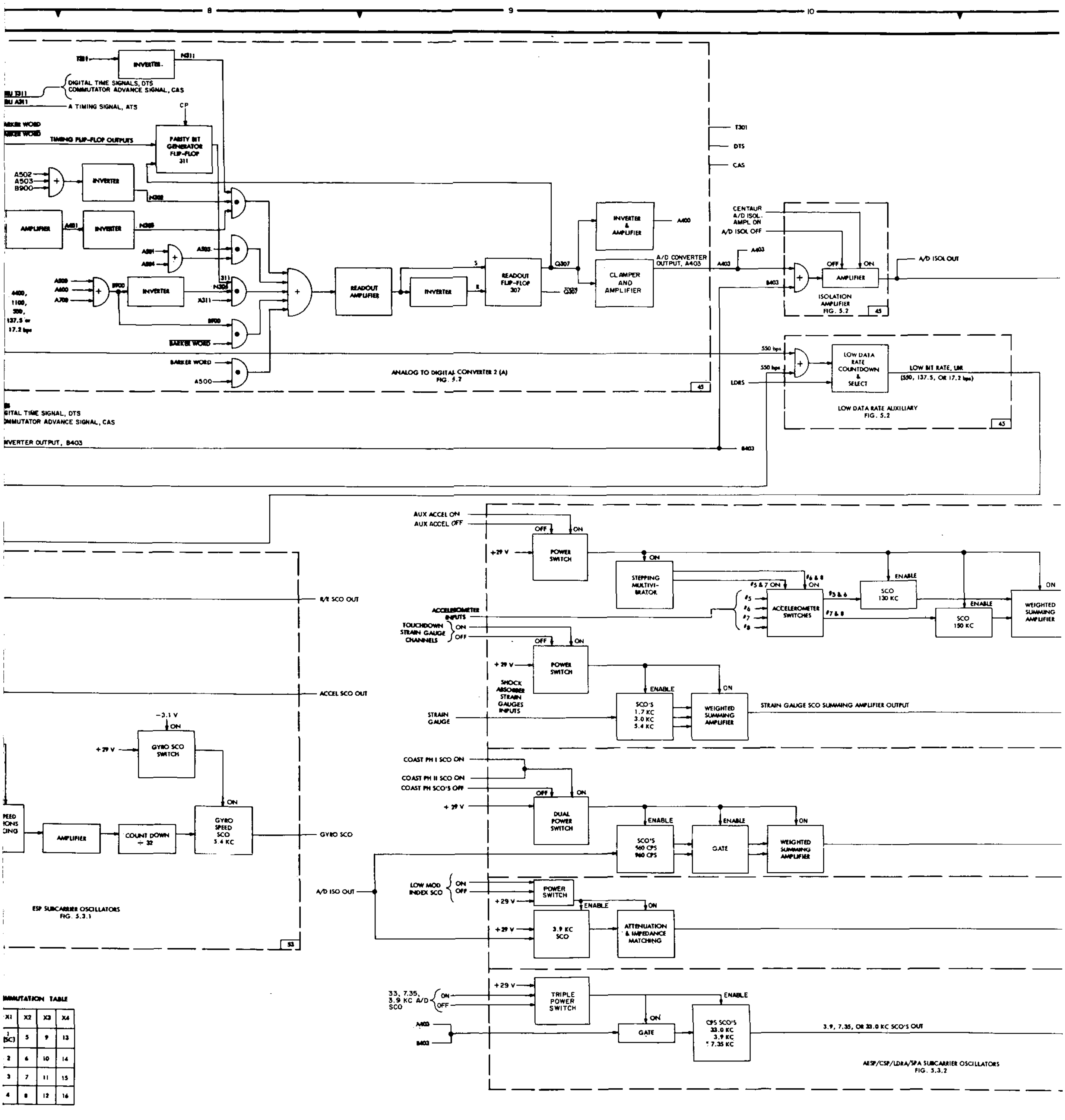
	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10
Y1	00 (S)	9	19	29	39	49	59	69	79	89
Y2	0 (SC)	10	20	30	40	50	60	70	80	90
Y3	1	11	21	31	41	51	61	71	81	91
Y4	2	12	22	32	42	52	62	72	82	92
Y5	3	13	23	33	43	53	63	73	83	93
Y6	4	14	24	34	44	54	64	74	84	94
Y7	5	15	25	35	45	55	65	75	85	95
Y8	6	16	26	36	46	56	66	76	86	96
Y9	7	17	27	37	47	57	67	77	87	97
Y10	8	18	28	38	48	58	68	78	88	98

AESP WORD NO. COMMUTATION TABLE

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
Y1	1	11	21	31	41	51	61	71	81	91	101	111
Y2	2	12	22	32	42	52	62	72	82	92	102	112
Y3	3	13	23	33	43	53	63	73	83	93	103	113
Y4	4	14	24	34	44	54	64	74	84	94	104	114
Y5	5	15	25	35	45	55	65	75	85	95	105	115
Y6	6	16	26	36	46	56	66	76	86	96	106	116
Y7	7	17	27	37	47	57	67	77	87	97	107	117
Y8	8	18	28	38	48	58	68	78	88	98	108	118 SYNC
Y9	9	19	29	39	49	59	69	79	89	99	109	119 (SC)
Y10	10	20	30	40	50	60	70	80	90	100	110	120 SYNC

TVA C

Y1
Y2
Y3
Y4



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INVERTER
DIGITAL TIME SIGNALS, DTS
COMMUTATOR ADVANCE SIGNAL, CAS
A TIMING SIGNAL, ATS
CP
TIMING FLIP-FLOP OUTPUTS
PARITY BIT GENERATOR FLIP-FLOP 311
A502
A503
B900
INVERTER
AMPLIFIER
INVERTER
READOUT AMPLIFIER
INVERTER
READOUT FLIP-FLOP 307
INVERTER & AMPLIFIER
CLAMPER AND AMPLIFIER
A/D CONVERTER OUTPUT, A403
ANALOG TO DIGITAL CONVERTER 2 (A) FIG. 5.2
BARKER WORD
A500
T301
DTS
CAS
CENTAUR A/D ISOL. AMPL ON
A/D ISOL OFF
AMPLIFIER
ISOLATION AMPLIFIER FIG. 5.2
A/D ISOL OUT
550 bps
LOW DATA RATE COUNTDOWN & SELECT
LOW BIT RATE, LBR
(550, 137.5, OR 17.2 bps)
LDRS
LOW DATA RATE AUXILIARY FIG. 5.2
DIGITAL TIME SIGNAL, DTS
COMMUTATOR ADVANCE SIGNAL, CAS
INVERTER OUTPUT, B403
B403
R/E SCO OUT
ACCEL SCO OUT
GYRO SCO SWITCH
AMPLIFIER
COUNT DOWN ÷ 32
GYRO SPEED SCO 5.4 KC
GYRO SCO
ESP SUBCARRIER OSCILLATORS FIG. 5.3.1
AUX ACCEL ON
AUX ACCEL OFF
POWER SWITCH
STEPPING MULTIVIBRATOR
ACCELEROMETER SWITCHES
SCO 130 KC
SCO 150 KC
WEIGHTED SUMMING AMPLIFIER
ACCELEROMETER INPUTS
TOUCHDOWN STRAIN GAUGE CHANNELS
SHOCK ABSORBER STRAIN GAUGES INPUTS
STRAIN GAUGE
SCO'S 1.7 KC 3.0 KC 5.4 KC
STRAIN GAUGE SCO SUMMING AMPLIFIER OUTPUT
COAST PH I SCO ON
COAST PH II SCO ON
COAST PH SCO'S OFF
DUAL POWER SWITCH
SCO'S 560 CPS 960 CPS
GATE
A/D ISO OUT
LOW MOD INDEX SCO
3.9 KC SCO
ATTENUATION & IMPEDANCE MATCHING
33, 7.35, 3.9 KC A/D SCO
TRIPLE POWER SWITCH
CPS SCO'S 33.0 KC 3.9 KC 7.35 KC
3.9, 7.35, OR 33.0 KC SCO'S OUT
AESP/CSP/LDRA/SPA SUBCARRIER OSCILLATORS FIG. 5.3.2
COMMUTATION TABLE

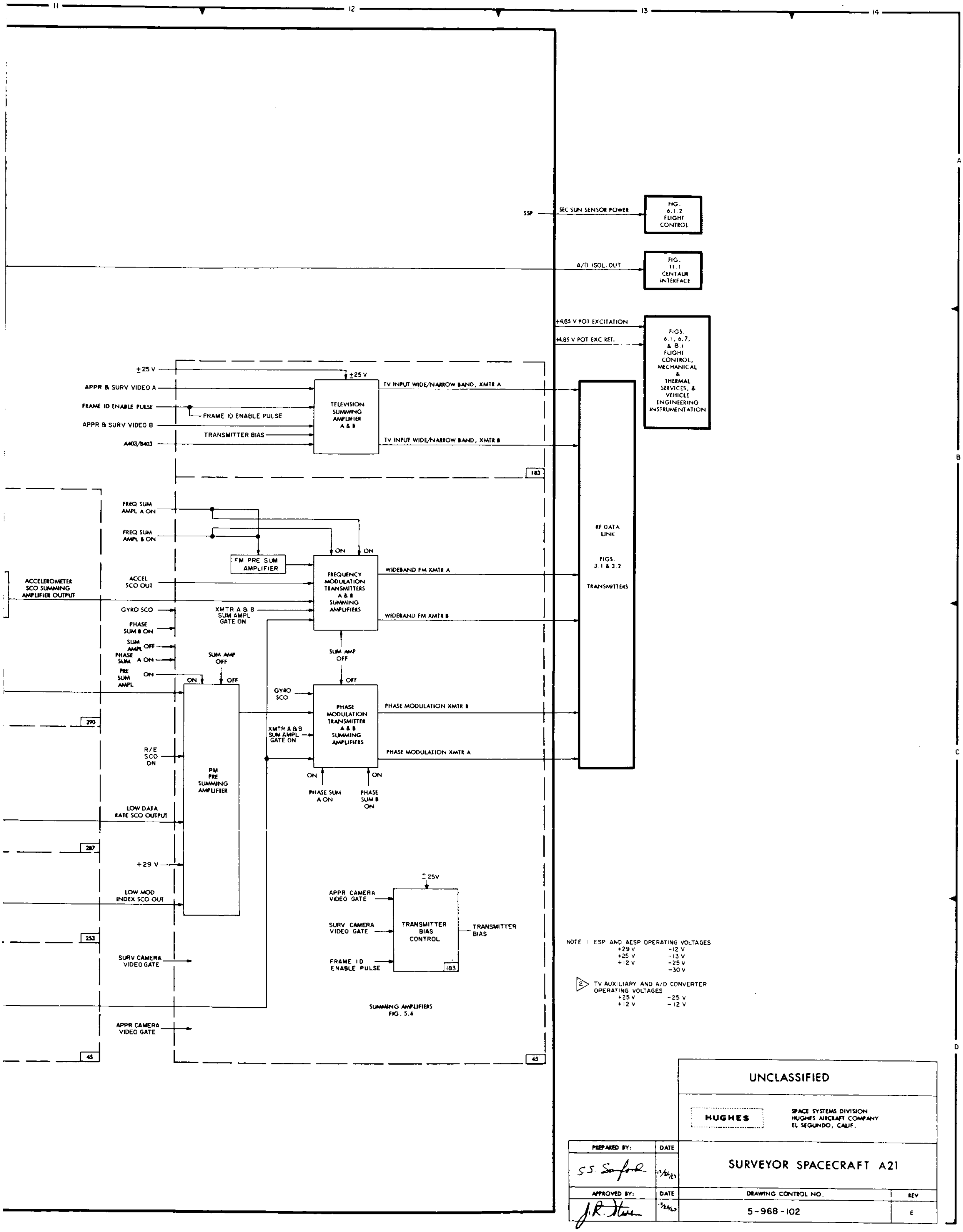

Figure 5.0. Signal Processing, Functional Block Diagram

SECTION VI

FLIGHT CONTROL

This section contains functional block diagrams and general functional theory for the FLIGHT CONTROL FUNCTION. Functional schematic diagrams and functional theory are included in Section VI of Volume II.

6.1 FLIGHT CONTROL FUNCTION. (Fig. 6.0)

Prepared by Eugene J. Bennett date 17 Nov 64
Approved by A. L. Neil date 17 Nov 64

The FLIGHT CONTROL FUNCTION consists of equipment within the Flight Control Sensor Group, Secondary Sun Sensor, Attitude Jets, Roll Actuator, Planar Array, Altitude Marking Radar, RADVS items, Vernier Engine items, and the Retro Rocket.

The purpose of FLIGHT CONTROL is to control spacecraft flight parameters throughout the transit portion of the mission. FLIGHT CONTROL uses three forms of reference to perform its mission. These are Celestial Sensors, Inertial Sensors, and radar sensors. The outputs of each of these sensors are utilized by the Analog Electronics to create thrust commands which operate the propulsion systems on board the spacecraft. Flight Control Programming initiates and controls sequences within the remainder of the function. The propulsion systems are the Vernier Engines; the Attitude Gas Jets; and the Retro Rocket, which is ignited in response to a signal from a switch in the MECHANICAL & THERMAL SERVICES FUNCTION.

6.2 OPERATIONAL REQUIREMENTS.

Power for most of the FLIGHT CONTROL Electronics is supplied by 22v unregulated power from the MECHANICAL & THERMAL SERVICES FUNCTION and 29v flight control power from the POWER MANAGEMENT FUNCTION. The RADVS section requires the 22v output of a pyro switch in MECHANICAL & THERMAL SERVICES. In addition, FLIGHT CONTROL requires ground commands that initiate various sequences and perform manual operations.

6.3 OPERATIONAL THEORY.

6.4 Flight Control Sensors.

The Celestial Sensors allow the spacecraft to be locked to a specific orientation defined by the lines to the sun and the star Canopus and the angle between them. Initial search and acquisition of the sun is accomplished by the Secondary Sun Sensor. The Primary Sun Sensor then maintains the orientation with the sun line.

The Integrating Gyros provide for maintaining Spacecraft orientation inertially when the celestial references are not available. The Accelerometers measure the thrust levels of the spacecraft propulsion during midcourse correction and retro descent phases.

The Altitude Marking Radar provides a trigger pulse to initiate the retro staging sequence. RADVS is described in paragraph 6.9.

6.5 Programming.

The Flight Control Programmer generates a sequence of digital signals to control the modes of operation of the Analog Electronics, provides a prescribed sequence of output signals for retro staging, and generates time delays monitored by ground commands for attitude maneuvers, midcourse correction, and sun acquisition.

6.6 Analog Electronics.

The Analog Electronics convert the outputs of the various Flight Control Sensors into suitable thrust commands for the Vernier Engines and the Attitude Gas Jets and a deflection command to the Roll Actuator on Thrust Chamber No. 1. Mode switching within the Analog Electronics determines which sensor outputs are utilized and which Propulsion system will be actuated.

6.7 Power.

The Power circuits provide the a-c and d-c voltage required by FLIGHT CONTROL for power and bias. In addition, the "FC Remote Sensing" signal is sent to POWER MANAGEMENT to confirm the availability of 29v FC power. The "FC Unregulated Power Gates" are used to control the application of unregulated power to the SS&A switches in MECHANICAL & THERMAL SERVICES.

6.8 Propulsion.

The Attitude Jets are cold gas reaction devices which control the orientation of spacecraft attitude in all coordinates during coast phases of the flight. They are installed in opposing pairs on the ends of the Landing Gear.

The Vernier Engines supply a continuously variable thrust for control of the spacecraft velocity vector and controlled descent to the lunar surface. The Roll Actuator tilts the thrust axis of Thrust Chamber No. 1 away from the spacecraft roll axis for attitude and roll control during thrust phases of flight, i.e. when the Vernier Engines are operating and the Attitude Jets are not.

The Retro Rocket removes the major portion of the spacecraft approach velocity during descent. It is triggered by squibs which fire upon signal from the Programmer via squib firing circuits in MECHANICAL & THERMAL SERVICES.

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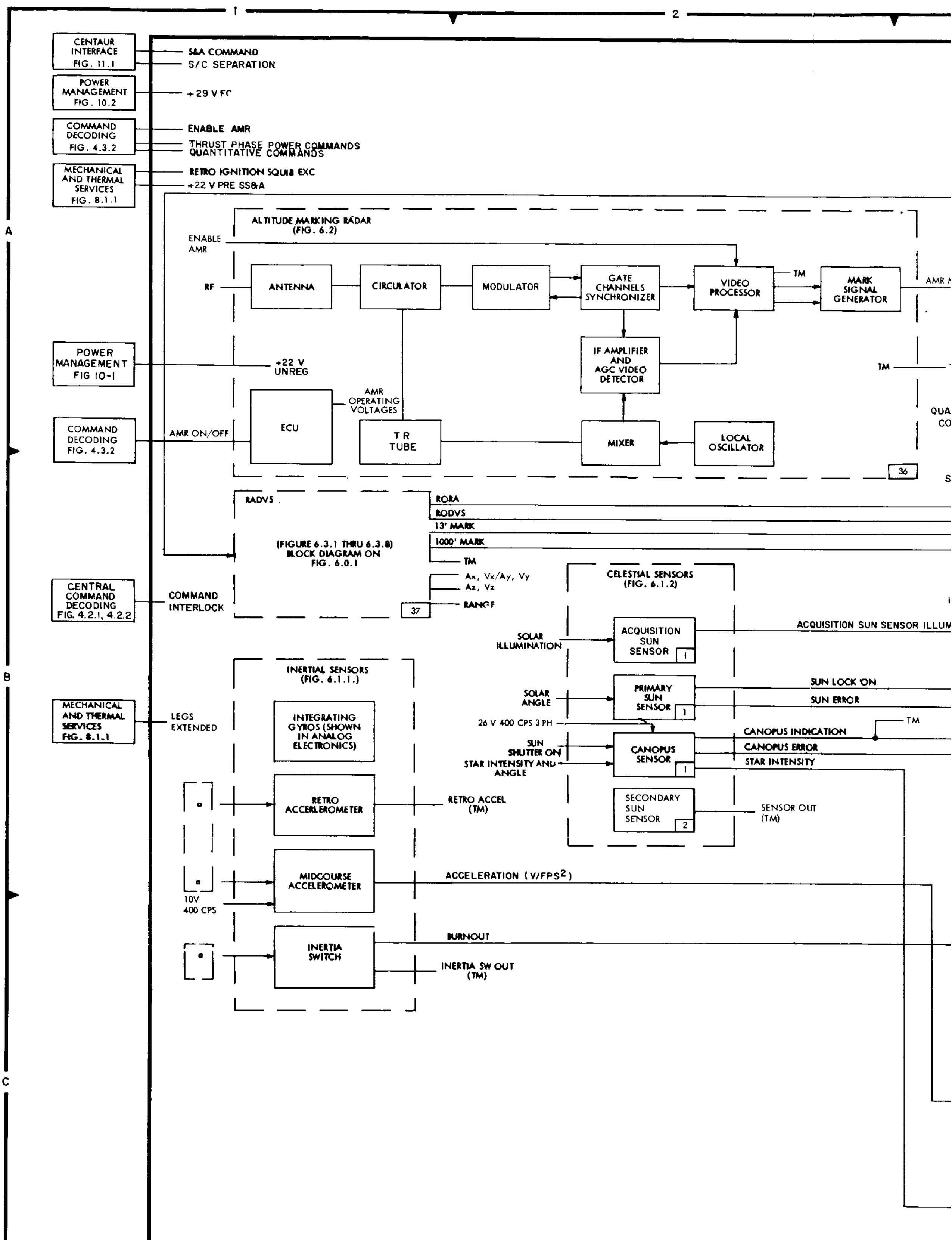
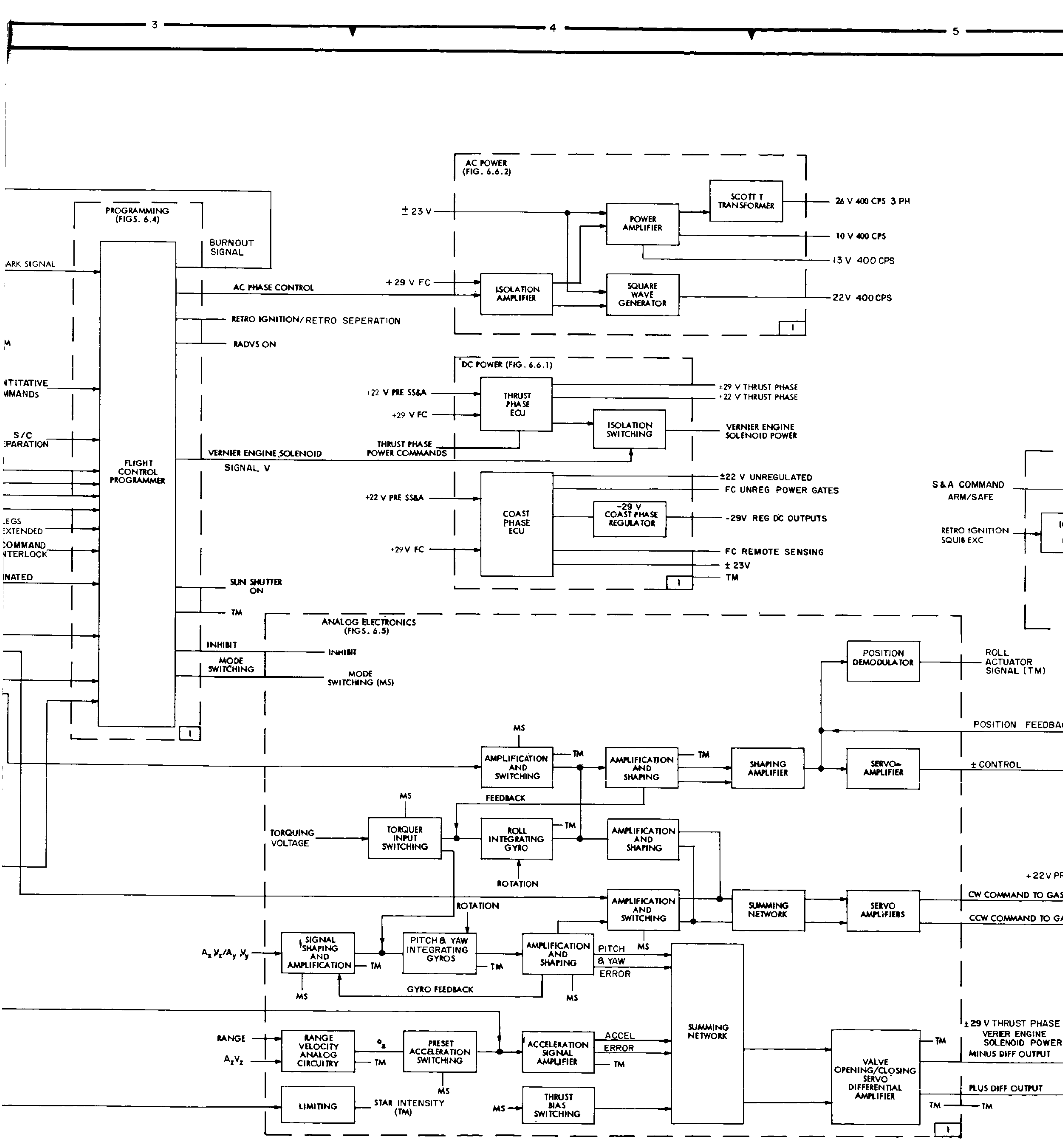


CENTAUR INTERFACE FIG. 11.1
POWER MANAGEMENT FIG. 10.2
COMMAND DECODING FIG. 4.3.2
MECHANICAL AND THERMAL SERVICES FIG. 8.1.1
S&A COMMAND
S/C SEPARATION
+29 V FC
ENABLE AMR
THRUST PHASE POWER COMMANDS
QUANTITATIVE COMMANDS
RETRO IGNITION SQUIB EXC
+22 V PRE SS&A
ALTITUDE MARKING RADAR (FIG. 6.2)
ENABLE AMR
RF
ANTENNA
CIRCULATOR
MODULATOR
GATE CHANNELS SYNCHRONIZER
VIDEO PROCESSOR
TM
MARK SIGNAL GENERATOR
IF AMPLIFIER AND AGC VIDEO DETECTOR
POWER MANAGEMENT FIG 10-1
+22 V UNREG
AMR OPERATING VOLTAGES
ECU
COMMAND DECODING FIG. 4.3.2
AMR ON/OFF
T R TUBE
MIXER
LOCAL OSCILLATOR
36
RADVS
RORA
RODVS
13' MARK
1000' MARK
TM
(FIGURE 6.3.1 THRU 6.3.8) BLOCK DIAGRAM ON FIG. 6.0.1
Ax, Vx/Ay, Vy
Az, Vz
RANGE
37
CENTRAL COMMAND DECODING FIG. 4.2.1, 4.2.2
COMMAND INTERLOCK
CELESTIAL SENSORS (FIG. 6.1.2)
SOLAR ILLUMINATION
ACQUISITION SUN SENSOR
ACQUISITION SUN SENSOR ILLUM
SOLAR ANGLE
PRIMARY SUN SENSOR
SUN LOCK ON
SUN ERROR
26 V 400 CPS 3 PH
SUN SHUTTER ON
STAR INTENSITY AND ANGLE
CANOPUS SENSOR
CANOPUS INDICATION
CANOPUS ERROR
STAR INTENSITY
SECONDARY SUN SENSOR
SENSOR OUT (TM)
INERTIAL SENSORS (FIG. 6.1.1.)
MECHANICAL AND THERMAL SERVICES FIG. 8.1.1
LEGS EXTENDED
INTEGRATING GYROS (SHOWN IN ANALOG ELECTRONICS)
RETRO ACCELEROMETER
RETRO ACCEL (TM)
MIDCOURSE ACCELEROMETER
ACCELERATION (V/FPS2)
10V 400 CPS
INERTIA SWITCH
BURNOUT
INERTIA SW OUT (TM)


3
4
5
AC POWER (FIG. 6.6.2)
± 23 V
POWER AMPLIFIER
SCOTT T TRANSFORMER
26 V 400 CPS 3 PH
10 V 400 CPS
13 V 400 CPS
+29 V FC
ISOLATION AMPLIFIER
SQUARE WAVE GENERATOR
22V 400CPS
PROGRAMMING (FIGS. 6.4)
BURNOUT SIGNAL
ARK SIGNAL
AC PHASE CONTROL
RETRO IGNITION/RETRO SEPERATION
RADVS ON
DC POWER (FIG. 6.6.1)
+22 V PRE SS&A
+29 V FC
THRUST PHASE ECU
±29 V THRUST PHASE
+22 V THRUST PHASE
ISOLATION SWITCHING
VERNIER ENGINE SOLENOID POWER
THRUST PHASE POWER COMMANDS
TITATIVE MMANDS
S/C PARATION
FLIGHT CONTROL PROGRAMMER
VERNIER ENGINE SOLENOID SIGNAL V
±22 V UNREGULATED
FC UNREG POWER GATES
COAST PHASE ECU
-29 V COAST PHASE REGULATOR
-29V REG DC OUTPUTS
FC REMOTE SENSING
± 23V
TM
S&A COMMAND ARM/SAFE
RETRO IGNITION SQUIB EXC
EGS EXTENDED
COMMAND NTERLOCK
NATED
SUN SHUTTER ON
TM
ANALOG ELECTRONICS (FIGS. 6.5)
INHIBIT
MODE SWITCHING
INHIBIT
MODE SWITCHING (MS)
POSITION DEMODULATOR
ROLL ACTUATOR SIGNAL (TM)
POSITION FEEDBA
MS
AMPLIFICATION AND SWITCHING
TM
AMPLIFICATION AND SHAPING
TM
SHAPING AMPLIFIER
SERVO-AMPLIFIER
± CONTROL
MS
FEEDBACK
TORQUING VOLTAGE
TORQUER INPUT SWITCHING
ROLL INTEGRATING GYRO
TM
AMPLIFICATION AND SHAPING
ROTATION
+22 V PR
AMPLIFICATION AND SWITCHING
SUMMING NETWORK
SERVO AMPLIFIERS
CW COMMAND TO GAS
CCW COMMAND TO G
ROTATION
SIGNAL SHAPING AND AMPLIFICATION
PITCH & YAW INTEGRATING GYROS
AMPLIFICATION AND SHAPING
PITCH & YAW ERROR
MS
TM
TM
GYRO FEEDBACK
MS
MS
SUMMING NETWORK
± 29 V THRUST PHASE
VERIER ENGINE SOLENOID POWER
MINUS DIFF OUTPUT
RANGE
RANGE VELOCITY ANALOG CIRCUITRY
PRESET ACCELERATION SWITCHING
ACCELERATION SIGNAL AMPLIFIER
ACCEL ERROR
TM
TM
VALVE OPENING/CLOSING SERVO DIFFERENTIAL AMPLIFIER
TM
PLUS DIFF OUTPUT
TM
TM
MS
LIMITING
STAR INTENSITY (TM)
MS
THRUST BIAS SWITCHING
1
1
1
1

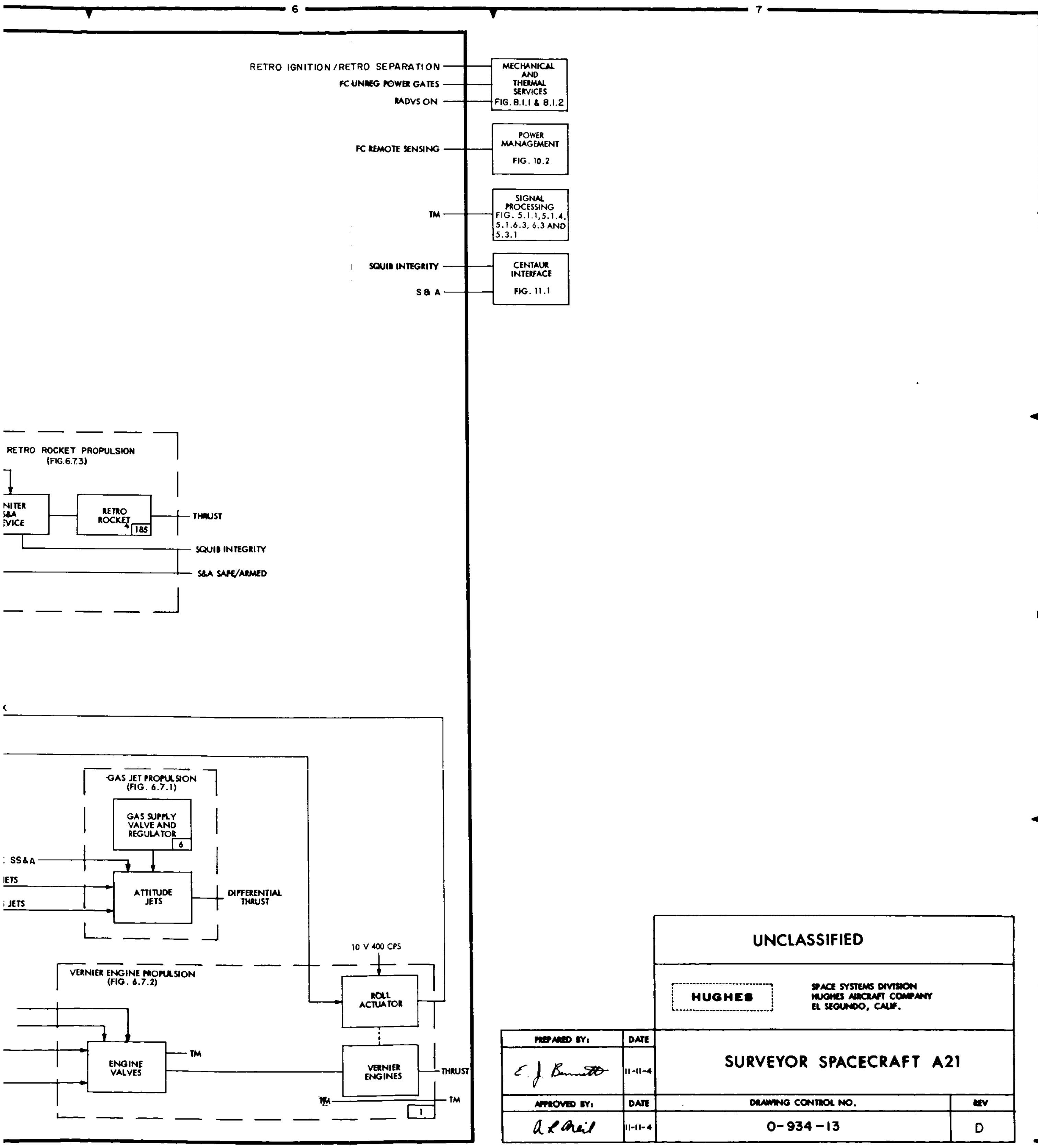


Figure 6.0. Flight Control, Functional Block Diagram

6.9 RADAR ALTIMETER AND DOPPLER VELOCITY SENSOR (RADVS) (Fig. 6.0.1)

Prepared by Harvey R. Seffner date November 17, 1964
Approved by R L Reid date Nov 17, 1964

6.10 GENERAL.

The RADVS functions in the FLIGHT CONTROL SUBSYSTEM to provide three-axis velocity, range, and altitude mark signals for flight control during the retro and vernier phases. The RADVS consists of a Doppler Velocity Sensor, which computes velocity along each the S/C X, Y, and Z axes, and a Radar Altimeter, which computes slant range from 40,000 ft. to 13 ft. and generates 1000 ft. and 13 ft. mark signals. The RADVS comprises four assemblies: 1) Klystron Power Supply/Modulator (KPSM), which contains the RA and DVS klystrons, klystron power supplies, and altimeter modulator; 2) Altimeter/Velocity Sensor Antenna, which contains beams 1 and 4 transmitting and receiving antennas and preamplifiers; 3) RADVS Velocity Sensing Antenna, which contains beams 2 and 3 transmitting antennas and preamplifiers; 4) RADVS Signal Data Converter, which consists of the electronics to convert doppler shift signals into dc analog signals.

6.11 OPERATIONAL REQUIREMENTS.

The RADVS accepts +22v unregulated from the "Pyro Switch Output 22v" line from the Engineering Mechanisms Auxiliary unit. A pyrotechnic switch in the EMA turns the RADVS power on at about 50 miles and off at about 13 ft.

6.12 OPERATIONAL THEORY.

6.13 Doppler Velocity Sensor Theory

The DVS operates on the principle that a reflected signal has a doppler frequency shift proportional to the approaching velocity. The reflected signal frequency is higher than the transmitted frequency for the closing condition. Three beams directed toward the lunar surface enable velocities in an orthogonal coordinate system to be determined.

6.14 DVS Klystron, and Velocity Sensor Antennas.

The KPSM provides an unmodulated DVS klystron output at a frequency of 13.3 kmc. This output is fed equally to the DVS1, DVS2, and DVS3 antennas. The RADVS Velocity Sensor Antenna unit and the Altimeter/Velocity Sensor Antenna unit provide both transmitting and receiving antennas for all three beams. The reflected signals are mixed with a small portion of the transmitted frequency at two points 3/4 wavelength apart for phase determination, detected and amplified by variable gain amplifiers providing 40db, 65db, or 90db of amplification, depending on received signal strength. The preamp output signals consist of two doppler frequencies shifted by 3/4 transmitted wavelength, and preamp gain state signals for each beam. The signals are routed to the trackers in the RADVS Signal Data Converter.

6.15 Signal Data Converter.

The D1 thru D3 trackers in the Signal Data Converter are similar in their operation. Each provides an output which is 600 kc plus the doppler frequency for approaching doppler shifts.

If no doppler signal is present, the tracker will operate in search mode, scanning frequencies between 82 kc and 800 cps before retro burnout, or between 22 kc and 800 cps after burnout. When a doppler shift is obtained, the tracker will operate as described above, and initiate a "Lockon" signal. The tracker also determines amplitude of the reflected signal and routes this information to the SIGNAL PROCESSING electronics for telemetry to DSIF.

The Cross Coupled Lobe Logic is necessary due to reflected signal interactions of the DVS2 and DVS3 signals, which are both received on the same antenna assembly. The cross-coupled signal is at least 30 db lower than the proper signal in either channel, and of the same doppler frequency. If two signals are within 100 cycles of the same frequency and at least 30 db apart, the Cross Coupled Lobe Logic utilizes preamplifier gain state information to determine which is the stronger signal. If only one signal is present, it determines which tracker should remain in track mode. In either case, a "Dual Time Constant" signal is routed to the other tracker, causing it to go into search mode.

The Velocity Converter combines tracker output signals to obtain dc analog signal corresponding to the S/C X, Y, and Z velocities. Thus, $f_c + D_3$ signal is subtracted from the $F_c + D_2$ signal to produce a frequency $D_2 - D_3$. This is converted into a dc signal, the voltage of which is proportional to $D_2 - D_3$, and the polarity of which is positive for positive Vy, and negative for negative Vy. In like manner $f_c + D_2$ is subtracted from $f_c + D_1$ to produce a dc analog signal V_X. To obtain V_Z, $f_c + D_1$ is added to $f_c + D_3$ to produce a sum frequency $D_1 + D_3$, which is converted also into a dc analog signal. $D_1 + D_3$ is also sent to the altimeter converter to compute range.

Range Mark, Reliability, and Reference Circuits produce a "Reliable Operate" (RODVS) signal if D_1 thru D_3 lockon signals are present, or if any of these signals are present three seconds after retro burnout. The RODVS signal is routed to the flight control electronics and to SIGNAL PROCESSING function for DSIF telemetry.

6.16 Radar Altimeter Theory

Slant range is determined by measuring the reflection time delay between the transmitted and received signals. The transmitted signal is frequency modulated at a constantly changing rate so that return signals can be identified.

6.17 KPS/M and Altimeter/Velocity Sensor Antenna.

The altimeter klystron has 1/4 watt output at a frequency of 12.9 kmc, which is deviated linearly by a sawtooth at a repitition rate of 180 cps by the altimeter modulator. The RF signal is radiated, and the reflected signal is received by the Altimeter/Velocity Sensor Antenna. The received signal is mixed with two samples of transmitted energy 3/4 wavelength apart, detected, and amplified by 40 db, 65 db, or 90 db in the altimeter preamp, depending on signal strength. The signals produced are difference frequencies resulting from the time lag between transmitted and received signals of a known shift rate, coupled with an additional doppler frequency shift because of the S/C velocity. These signals along with the preamp gain state signals are routed to the tracker in the RADVS Signal Data Converter for processing.

6.18 Signal Data Converter.

The Altimeter Tracker in the Signal Data Converter accepts doppler shift signals and gain state signals from the Altimeter/Velocity Sensor Antenna and converts these into a signal $f_c+p_r+f_d$, which is 600 kc plus the range frequency plus the doppler frequency. This signal is routed to the Altimeter Converter for range dc analog signal generation.

The Altimeter Converter subtracts f_c, which comes from the Velocity Converter, from $f_c+p_r+f_d$ to obtain p_r+f_d, from which it subtracts an analog of f_d which comes from the Felocity Converter, to obtain p_r the range signal. The Altimeter Converter then converts p_r into a dc analog of the range A_ZR_Z. Signal A_ZR_Z is routed to the Range Mark, Reliability, and Reference Circuits for altitude mark signal operation, and to the flight control electronics for engine thrust control.

The Range Mark, Reliability, and Reference Circuits produce the 1000 ft mark signal RA1K and the 13 ft mark signal RA13 from the range signal, generated by the Altimeter Converter. The circuits also generate an altimeter reliable signal (RORA) if the altimeter, D1 and D3 trackers, are in the track mode. The circuits require RORA, to be present or the range mark signals RA1K and RA13 will not be generated. The circuits also generate a KPSM deviation control signal from RA1K which changes the klystron deviation from 4 mc to 40 mc below 1000 ft. RA1K, RA13, and RORA are routed to flight control electronics. RA1K is used to re-scale the range signal, RA13 is used for Vernier shutoff, and RORA indicates to the flight control electronics whether or not the range signal is reliable. Also RORA is routed to SIGNAL PROCESSING for transmission to DSIF.

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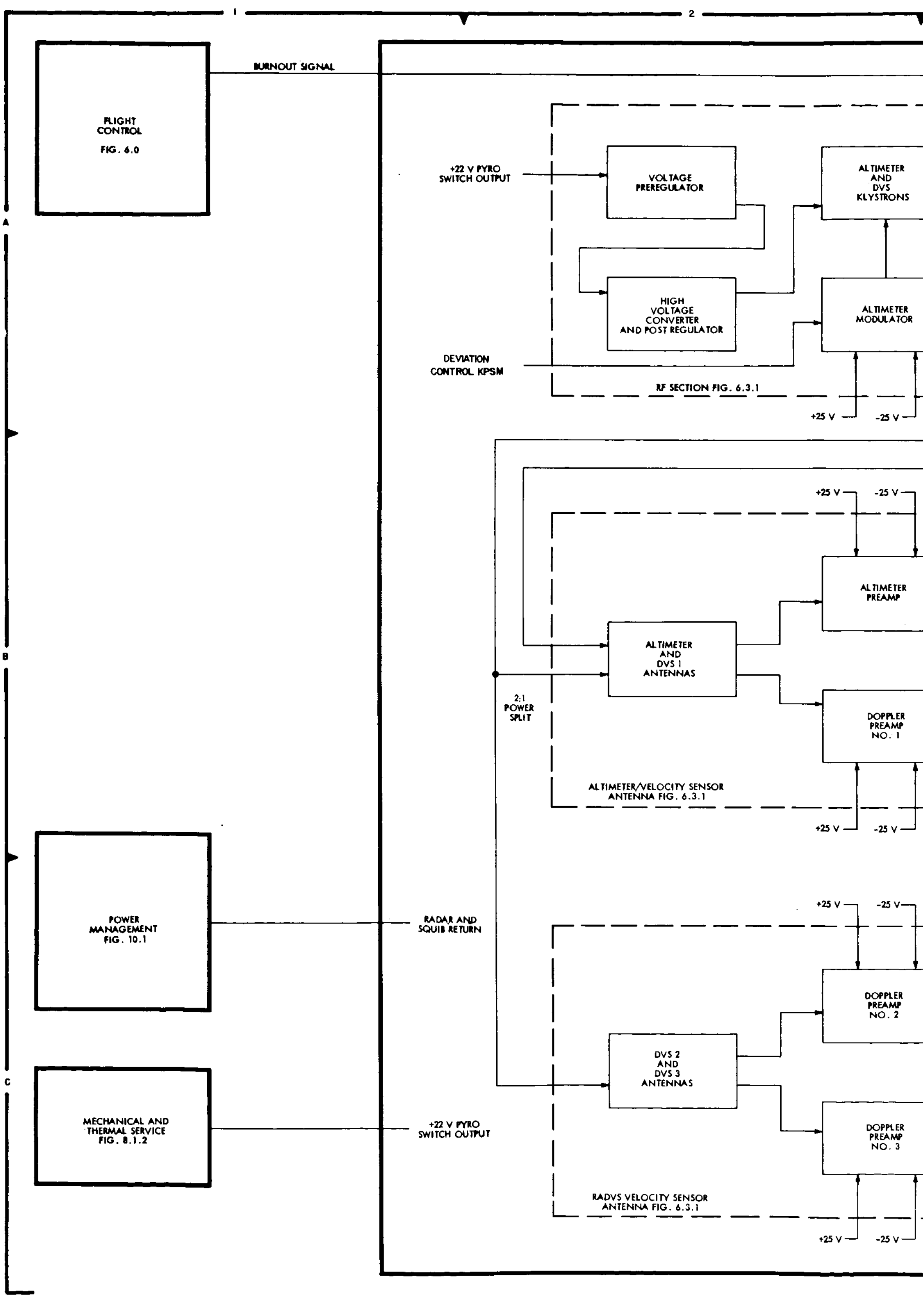
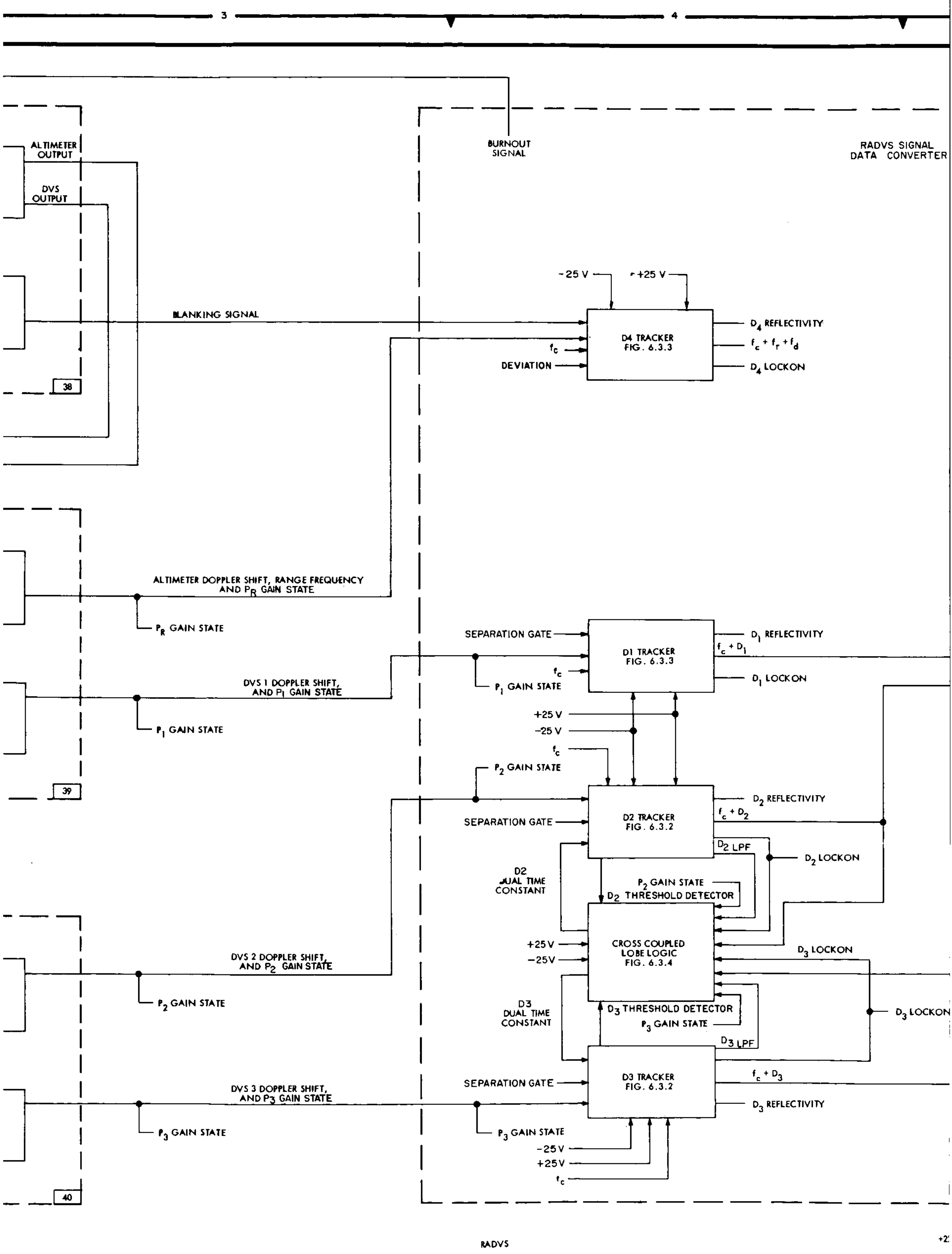
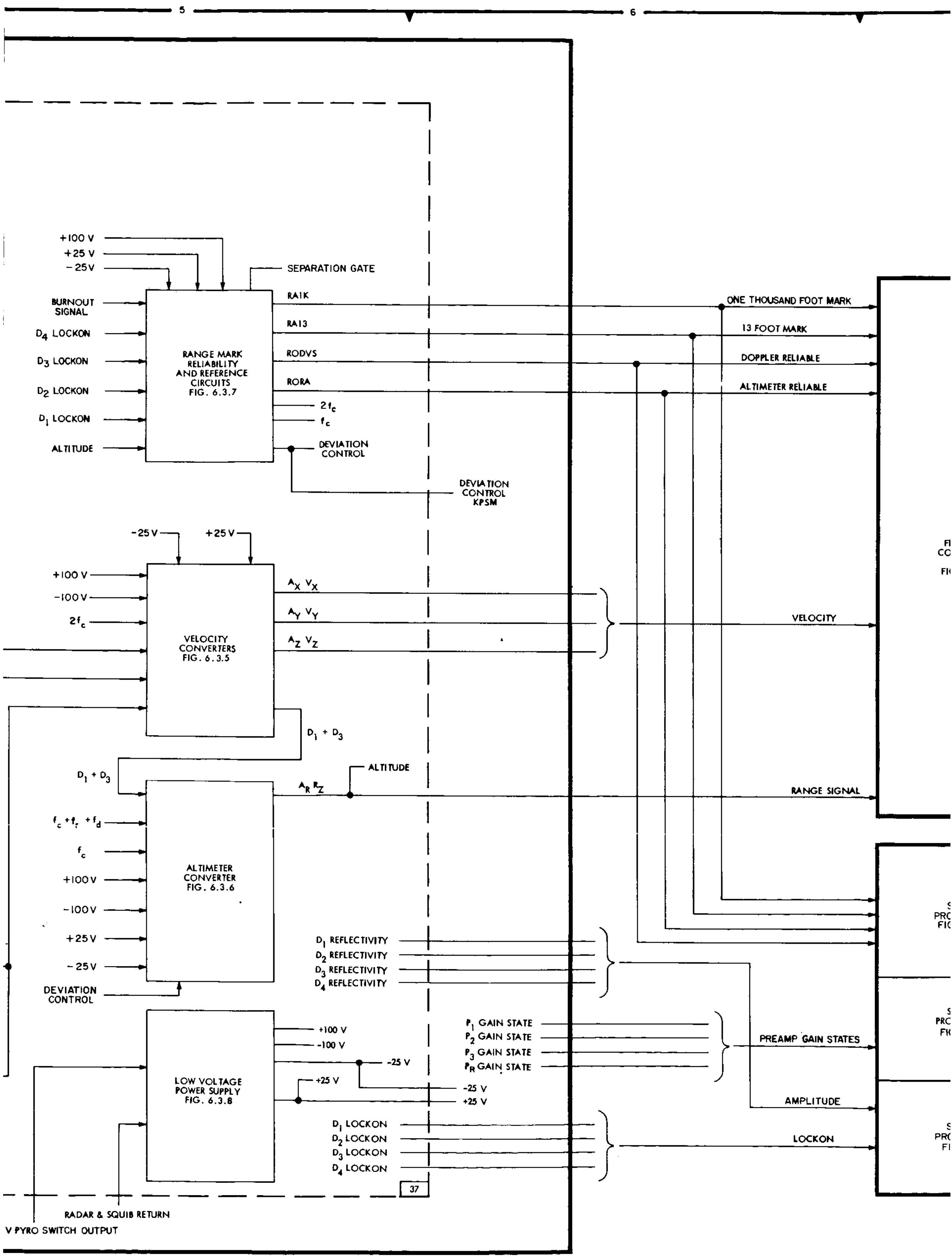

1
2
A
B
C
FLIGHT CONTROL FIG. 6.0
BURNOUT SIGNAL
+22 V PYRO SWITCH OUTPUT
VOLTAGE PREREGULATOR
ALTIMETER AND DVS KLYSTRONS
HIGH VOLTAGE CONVERTER AND POST REGULATOR
ALTIMETER MODULATOR
DEVIATION CONTROL KPSM
RF SECTION FIG. 6.3.1
+25 V
-25 V
ALTIMETER PREAMP
ALTIMETER AND DVS 1 ANTENNAS
2:1 POWER SPLIT
DOPPLER PREAMP NO. 1
ALTIMETER/VELOCITY SENSOR ANTENNA FIG. 6.3.1
POWER MANAGEMENT FIG. 10.1
RADAR AND SQUIB RETURN
DOPPLER PREAMP NO. 2
DVS 2 AND DVS 3 ANTENNAS
MECHANICAL AND THERMAL SERVICE FIG. 8.1.2
+22 V PYRO SWITCH OUTPUT
DOPPLER PREAMP NO. 3
RADVS VELOCITY SENSOR ANTENNA FIG. 6.3.1



3
4
ALTIMETER OUTPUT
DVS OUTPUT
BURNOUT SIGNAL
RADVS SIGNAL DATA CONVERTER
-25 V
+25 V
BLANKING SIGNAL
D4 TRACKER FIG. 6.3.3
fc
DEVIATION
D4 REFLECTIVITY
fc + fr + fd
D4 LOCKON
38
ALTIMETER DOPPLER SHIFT, RANGE FREQUENCY AND PR GAIN STATE
PR GAIN STATE
SEPARATION GATE
D1 TRACKER FIG. 6.3.3
P1 GAIN STATE
D1 REFLECTIVITY
fc + D1
D1 LOCKON
DVS 1 DOPPLER SHIFT, AND P1 GAIN STATE
P1 GAIN STATE
+25 V
-25 V
fc
P2 GAIN STATE
39
D2 TRACKER FIG. 6.3.2
D2 REFLECTIVITY
fc + D2
D2 LPF
D2 LOCKON
D2 DUAL TIME CONSTANT
P2 GAIN STATE
D2 THRESHOLD DETECTOR
CROSS COUPLED LOBE LOGIC FIG. 6.3.4
D3 LOCKON
DVS 2 DOPPLER SHIFT, AND P2 GAIN STATE
P2 GAIN STATE
D3 DUAL TIME CONSTANT
D3 THRESHOLD DETECTOR
P3 GAIN STATE
D3 LPF
D3 TRACKER FIG. 6.3.2
fc + D3
D3 REFLECTIVITY
DVS 3 DOPPLER SHIFT, AND P3 GAIN STATE
P3 GAIN STATE
40
RADVS



5
6
+100 V
+25 V
-25V
SEPARATION GATE
BURNOUT SIGNAL
D4 LOCKON
D3 LOCKON
D2 LOCKON
D1 LOCKON
ALTITUDE
RANGE MARK RELIABILITY AND REFERENCE CIRCUITS FIG. 6.3.7
RA1K
RA13
RODVS
RORA
2fc
fc
DEVIATION CONTROL
DEVIATION CONTROL KPSM
ONE THOUSAND FOOT MARK
13 FOOT MARK
DOPPLER RELIABLE
ALTIMETER RELIABLE
-25 V
+25 V
+100 V
-100 V
2fc
VELOCITY CONVERTERS FIG. 6.3.5
AX VX
AY VY
AZ VZ
VELOCITY
D1 + D3
D1 + D3
ALTITUDE
AR RZ
RANGE SIGNAL
fc + fr + fd
fc
+100 V
-100 V
+25 V
-25 V
DEVIATION CONTROL
ALTIMETER CONVERTER FIG. 6.3.6
D1 REFLECTIVITY
D2 REFLECTIVITY
D3 REFLECTIVITY
D4 REFLECTIVITY
LOW VOLTAGE POWER SUPPLY FIG. 6.3.8
+100 V
-100 V
-25 V
+25 V
P1 GAIN STATE
P2 GAIN STATE
P3 GAIN STATE
PR GAIN STATE
PREAMP GAIN STATES
-25 V
+25 V
AMPLITUDE
D1 LOCKON
D2 LOCKON
D3 LOCKON
D4 LOCKON
LOCKON
37
RADAR & SQUIB RETURN
V PYRO SWITCH OUTPUT

6-8-3

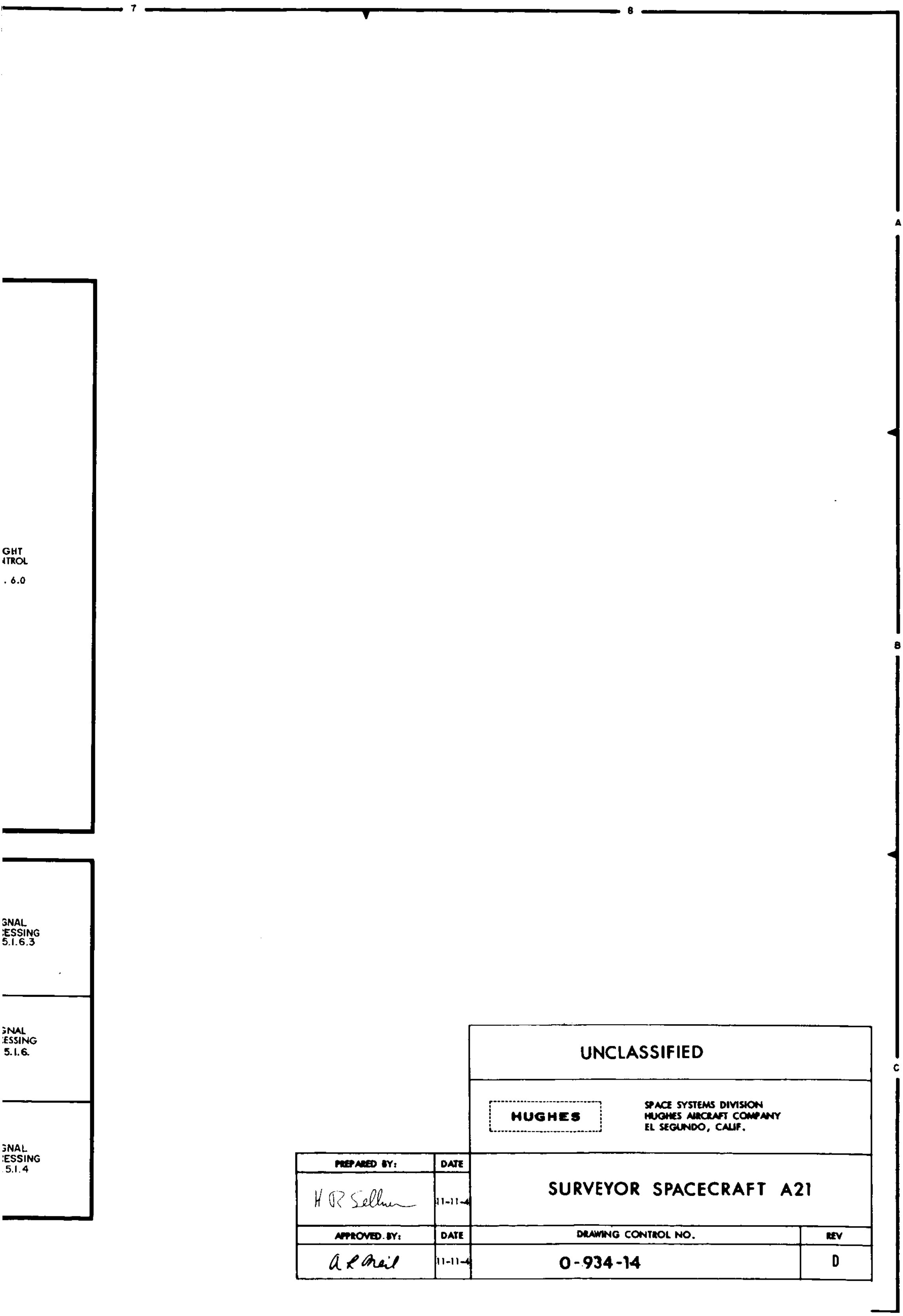


Figure 6.0.1. RADVS, Functional Block Diagram

SECTION VII

TELEVISION CAMERAS

This section contains functional block diagrams and general functional theory for the Television Cameras. Functional schematic diagrams and functional theory are included in Section VII of Volume II.

7.0 TELEVISION CAMERAS. (Fig. 7.0.)

Prepared by D.W. Demarell date 10-17-64

Approved by FJ Wolf date 18 Nov 64

This section contains the functional theory and functional diagrams for the two television cameras of the Surveyor Spacecraft A21. The Survey Television Camera will be used after the spacecraft has landed on the moon. The Approach Television Camera is operated during the spacecraft terminal descent.

7.1 SURVEY TELEVISION CAMERA.

7.2 General.

Survey Television Camera provides the capability of observing the lunar surface, portions of the spacecraft, and large sections of free space, on command from earth. The camera can be commended to alter its angular field of view and to change the angular orientation of the center of the field of view with respect to the basic spacecraft coordinate system. Provisions are made for inserting colored or polarizing filters into the camera optical system on command from earth. The focus distance and lens aperture are adjustable on command from earth for variation in object distance and light intensity. Provision is also made to alter the lens opening (iris) either on direct command from earth or automatically as desired. Temperature sensing devices are also contained on the camera which give the temperature conditions.

Survey Television Camera converts optical images within its field of view into complete composite video signals which include horizontal and vertical synchronization and vertical blanking pulses. In performing this function, the camera is completely self-contained, requiring only electrical power inputs, and decoded commands from earth.

7.3 Operational Requirements.

Survey Television Camera may be operated in a 600 TV line normal mode or a 200 TV line emergency mode, the normal mode providing better quality at the expense of greater signal bandwidth. Two major command signals are transmitted to the camera during its operational sequence. "Survey Camera, Power On, 1103" and "Start Frame, 1100" commands. Additional commands are transmitted to the camera allowing remote control of various mechanisms.

Horizontal sync pulses are superimposed upon vertical blanking pulses, enabling synchronization of ground monitors prior to transmission of the camera video output. Single frame video readout of 1-second duration for normal mode and 20-second duration for emergency mode follows the first vertical blanking pulse. Two more erasure frames are generally allowed to follow video readout (video readout is the first erasure frame). However, if a start frame command is received by the spacecraft during the second erase frame, the picture taking sequence will be initiated in the normal manner but the picture will be degraded (due to improper erasure of the previous image). The three frame picture taking sequence requires nominally 3. 6 seconds for the normal mode and 61. 8 seconds for the emergency mode.

7. 4 OPERATIONAL THEORY.

7. 5 ELECTRONIC CONVERSION UNIT.

"Survey Camera Power On, 1103" command from COMMAND DECODING enables the ELECTRONIC CONVERSION UNIT (ECU). The ECU receives "+22 V Unregulated" and "+29 V Regulated Nonessential" from POWER MANAGEMENT and processes and distributes this power to the circuits of the Survey Television Camera.

7. 6 SWEEP, SYNC & BLANKING CIRCUITS.

The SWEEP, SYNC & BLANKING CIRCUITS generate: the synchronization and blanking pulses used throughout the camera for timing purposes; the current to drive the magnetic DEFLECTION YOKES which apply sweep to the VIDICON TUBE; and the vertical blanking pulses used in the VIDEO LOGIC circuitry. Normal or emergency modes of operation are available.

7. 7 VIDEO LOGIC.

The VIDEO LOGIC circuitry generates a signal which causes the camera shutter to open on the leading edge of the first vertical blanking pulse after the earth initiated "Start Frame, 1100" comand is received from COMMAND DECODING. Similarly, a signal is generated which causes the shutter to close on the trailing edge of the first vertical blanking pulse. VIDEO LOGIC also performs three other functions. One is the generation of an inhibit signal which prevents heating of the VIDICON faceplate during picture readout and third erase. The second VIDEO LOGIC function is high-low power control of the transmitters in the RF DATA LINK. The transmitters are turned on when there is a picture to be transmitted to earth and turned off during the second and third erase frames. Finally, VIDEO LOGIC transmits a signal to VIDICON THERMAL CONTROL CIRCUIT and VIDEO PROCESSING which allows the VIDEO PROCESSING output to be transmitted to SIGNAL PROCESSING when the video readout frame is to occur.

7.8 VIDEO PROCESSING.

The function of VIDEO PROCESSING is to remove the video from the VIDICON TUBE as the beam sweeps the faceplate and restore the dc video level. The enables the video to be combined with the horizontal sync and blanking pulses to form the composite video signal. VIDEO PROCESSING also receives sync and blanking pulses from the SWEEP, SYNC AND BLANKING CIRCUITS and the control signal from VIDEO LOGIC mentioned above. The composite video signal is then sent to the Television Auxiliary section of SIGNAL PROCESSING for transmission to earth.

7.9 Image Control Circuits.

The Image Control Circuits include the SHUTTER CONTROL; MIRROR CONTROL; FILTER, FOCUS AND FOCAL LENGTH CONTROLS; and the IRIS CONTROL. All four of these control circuits are controlled by COMMAND DECODING thus allowing adjustment of the various mechanisms remotely from earth. The SHUTTER CONTROL and IRIS CONTROL are also controlled by VIDEO LOGIC with a "Frame ID Enable Signal And Shutter Reset" signal.

Outputs from the Image Control Circuits and mechanisms are sent to SIGNAL PROCESSING to be processed for transmission to earth. These signals give the states, positions, and settings of the equipment concerned.

7.10 VIDICON THERMAL CONTROL CIRCUIT.

The VIDICON THERMAL CONTROL CIRCUIT automatically provides the VIDICON TUBE heaters with the required power to maintain the VIDICON faceplate within a specified temperature range. The circuit receives the "Survey Camera Vidicon Temperature Control On/Off" signals from COMMAND DECODING which affords the option of remotely removing the power from the VIDICON TUBE heaters. The circuit also receives signals from VIDEO LOGIC. These signals were mentioned previously in the discussion of the VIDEO LOGIC section.

7.11 Temperature Sensor Circuits.

The VIDICON FACEPLATE AND CAMERA ELECTRONICS TEMPERATURE SENSOR circuits transmit voltages to the Television Auxiliary section of SIGNAL PROCESSING which are proportional to the temperatures detected. These signals, "Camera Electronics Temperature" and "Vidicon Faceplate Temperature," are then sent to earth.

7.12 APPROACH TELEVISION CAMERA.

7.13 General.

The purpose of the Approach Television Camera is to provide an overlapping set of pictures of the lunar surface during the spacecraft terminal descent. These pictures will be correlated with existing lunar photographs taken from earth and from spacecraft trajectory information to precisely determine the lunar landing position of the spacecraft. The Approach Television Camera consists of an Electronic Conversion Unit (ECU), Vidicon Tube, video sensing and control circuits, temperature sensing and control circuits and a shutter mechanism. The Approach Television Camera is a downward looking camera and has no mirrors for scanning sequences. It has a fixed focal length lens that is focused at infinity and a manually adjusted iris that is set before launch.

7.14 Operational Requirements.

The Approach Television Camera provides pictures during the approach phase of the mission. Pictures are taken between the time the terminal attitude maneuver is completed at approximately 1000 miles from the moon until the camera is turned off after touchdown. Two major command signals are transmitted to Approach Television Camera during its operational sequence: "Approach Camera Power On, 0132" and "Start Frame, Approach Camera, 0133." Receipt of these two commands by the camera initiates the picture taking sequence.

7.15 Operational Theory.

The theory of operation of Approach Television Camera is essentially the same as that of Survey Television Camera. Approach Television Camera does not have an emergency mode and therefore does not have EMERGENCY MODE SWEEP, SYNC, AND BLANKING CIRCUITS as does Survey Television Camera. There are also several Image Control Circuits contained in Survey Television Camera which do not appear in Approach Television Camera. These include the FILTER, FOCAL LENGTH, AND FOCUS CONTROLS; MIRROR CONTROL; and IRIS CONTROL. The remainder of the circuits are similar for both cameras, therefore refer to paragraph 7.4 for the operational theory.

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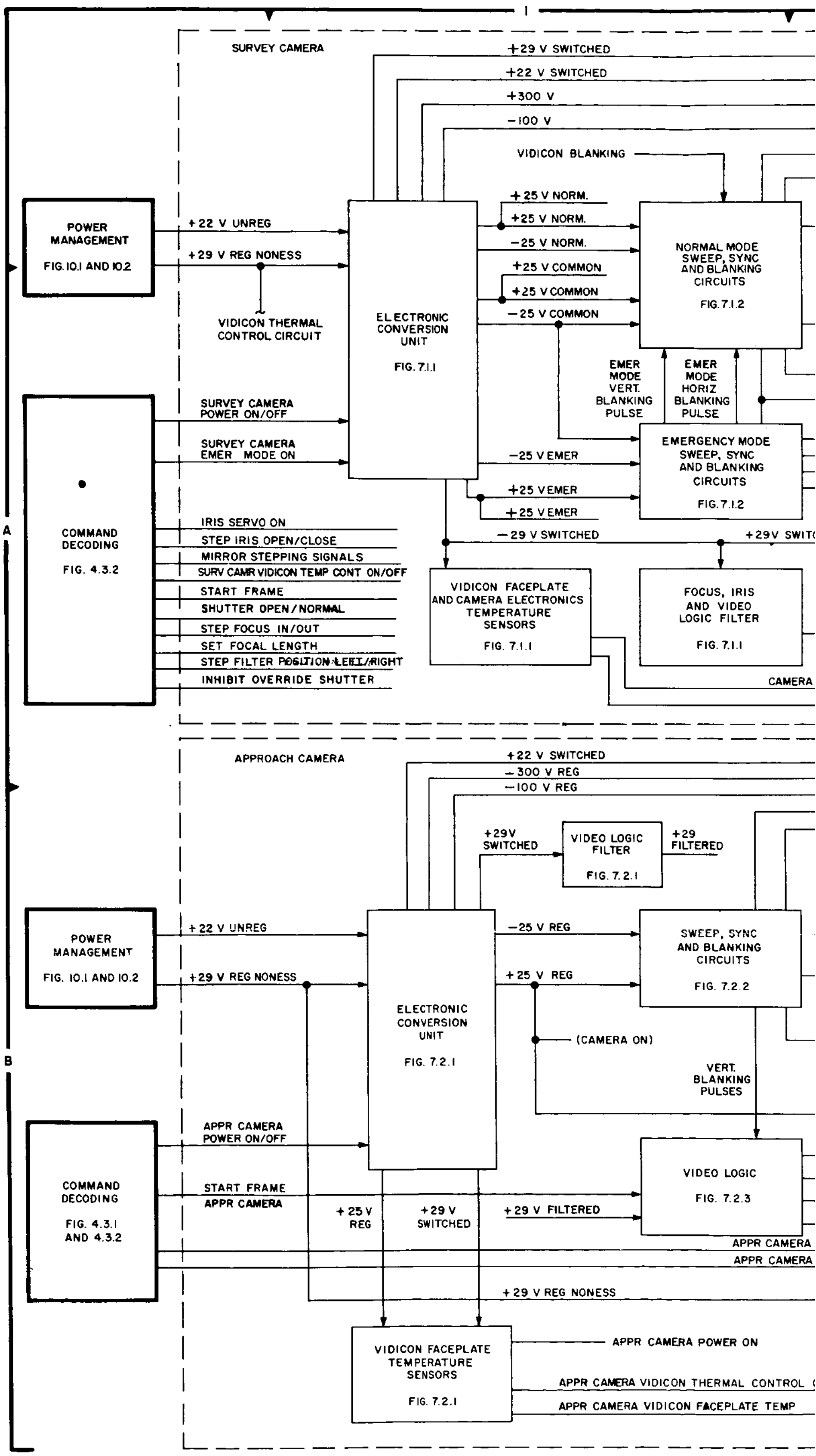
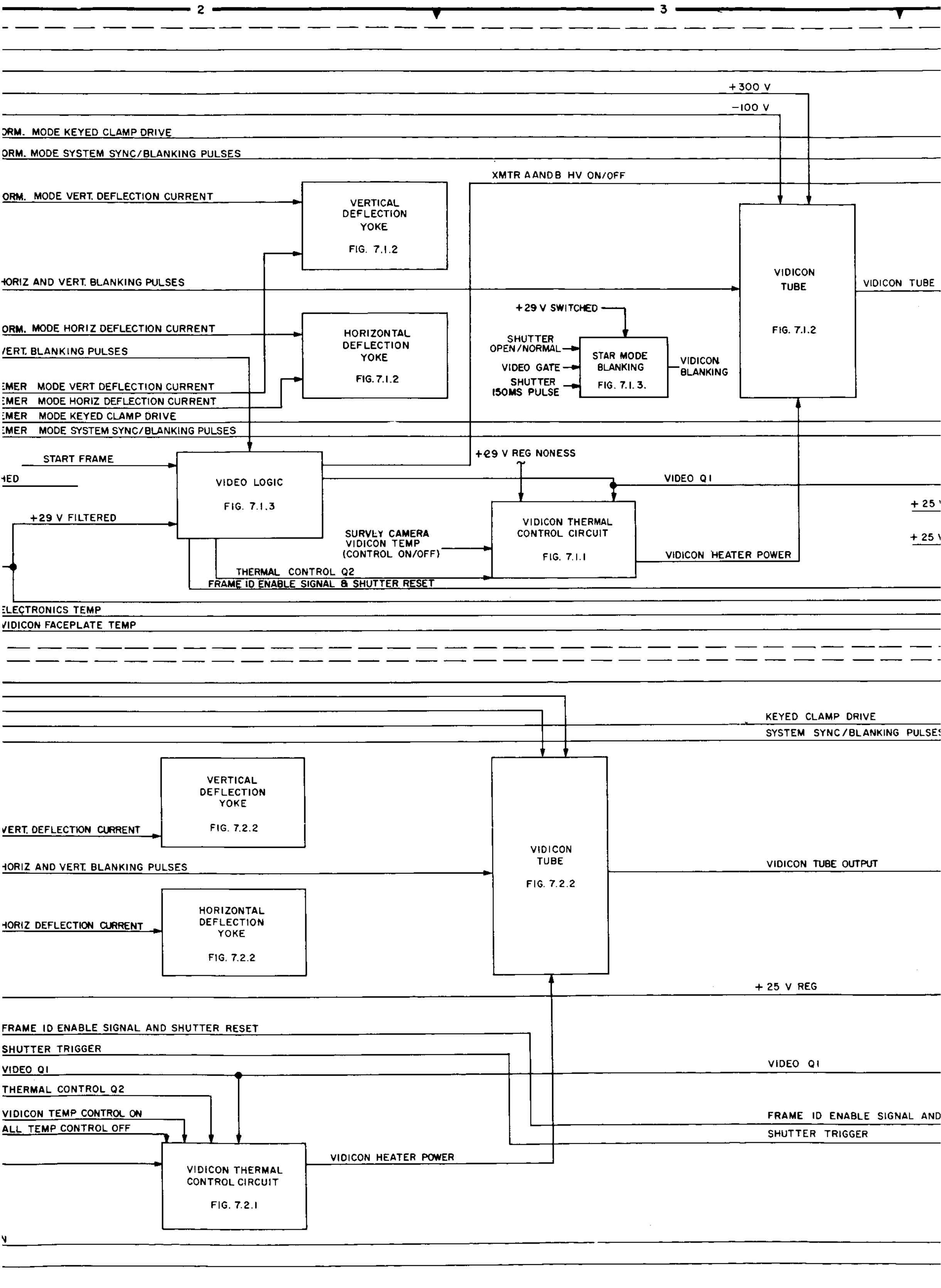
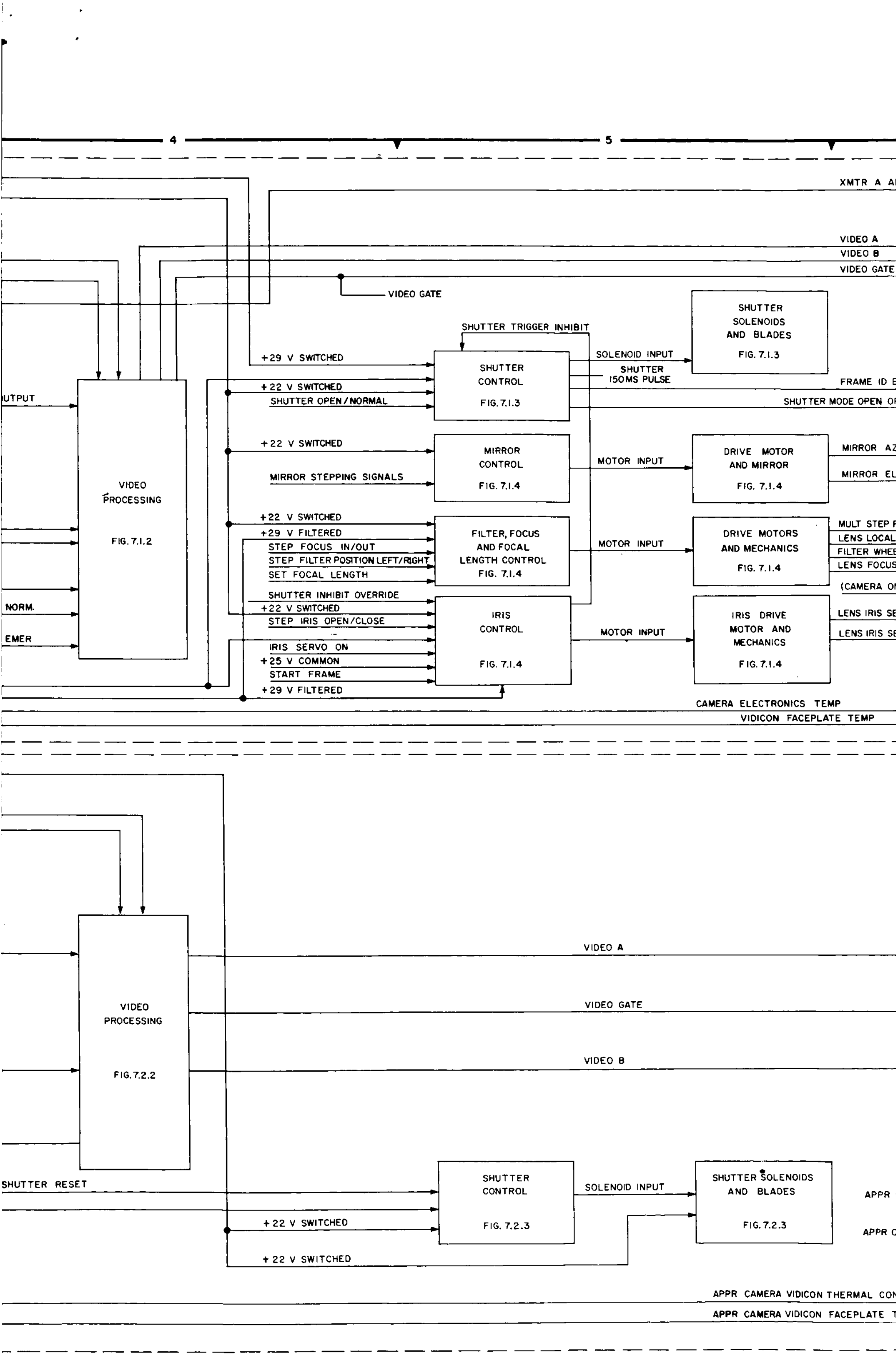


SURVEY CAMERA
+29 V SWITCHED
+22 V SWITCHED
+300 V
−100 V
VIDICON BLANKING
POWER MANAGEMENT FIG. 10.1 AND 10.2
+22 V UNREG
+29 V REG NONESS
VIDICON THERMAL CONTROL CIRCUIT
ELECTRONIC CONVERSION UNIT FIG. 7.1.1
+25 V NORM.
+25 V NORM.
−25 V NORM.
+25 V COMMON
+25 V COMMON
−25 V COMMON
NORMAL MODE SWEEP, SYNC AND BLANKING CIRCUITS FIG. 7.1.2
EMER MODE VERT. BLANKING PULSE
EMER MODE HORIZ BLANKING PULSE
EMERGENCY MODE SWEEP, SYNC AND BLANKING CIRCUITS FIG. 7.1.2
−25 V EMER
+25 V EMER
+25 V EMER
−29 V SWITCHED
+29V SWIT
SURVEY CAMERA POWER ON/OFF
SURVEY CAMERA EMER MODE ON
COMMAND DECODING FIG. 4.3.2
IRIS SERVO ON
STEP IRIS OPEN/CLOSE
MIRROR STEPPING SIGNALS
SURV CAMR VIDICON TEMP CONT ON/OFF
START FRAME
SHUTTER OPEN/NORMAL
STEP FOCUS IN/OUT
SET FOCAL LENGTH
STEP FILTER ~~POSITION LEFT~~/RIGHT
INHIBIT OVERRIDE SHUTTER
VIDICON FACEPLATE AND CAMERA ELECTRONICS TEMPERATURE SENSORS FIG. 7.1.1
FOCUS, IRIS AND VIDEO LOGIC FILTER FIG. 7.1.1
CAMERA
A
APPROACH CAMERA
+22 V SWITCHED
−300 V REG
−100 V REG
+29V SWITCHED
VIDEO LOGIC FILTER FIG. 7.2.1
+29 FILTERED
POWER MANAGEMENT FIG. 10.1 AND 10.2
+22 V UNREG
+29 V REG NONESS
ELECTRONIC CONVERSION UNIT FIG. 7.2.1
−25 V REG
+25 V REG
SWEEP, SYNC AND BLANKING CIRCUITS FIG. 7.2.2
(CAMERA ON)
VERT. BLANKING PULSES
B
COMMAND DECODING FIG. 4.3.1 AND 4.3.2
APPR CAMERA POWER ON/OFF
START FRAME APPR CAMERA
+25 V REG
+29 V SWITCHED
+29 V FILTERED
VIDEO LOGIC FIG. 7.2.3
APPR CAMERA
APPR CAMERA
+29 V REG NONESS
VIDICON FACEPLATE TEMPERATURE SENSORS FIG. 7.2.1
APPR CAMERA POWER ON
APPR CAMERA VIDICON THERMAL CONTROL
APPR CAMERA VIDICON FACEPLATE TEMP



2
3
+300 V
−100 V
ORM. MODE KEYED CLAMP DRIVE
ORM. MODE SYSTEM SYNC/BLANKING PULSES
XMTR A AND B HV ON/OFF
ORM. MODE VERT. DEFLECTION CURRENT
VERTICAL DEFLECTION YOKE FIG. 7.1.2
HORIZ AND VERT. BLANKING PULSES
VIDICON TUBE FIG. 7.1.2
VIDICON TUBE
+29 V SWITCHED
ORM. MODE HORIZ DEFLECTION CURRENT
HORIZONTAL DEFLECTION YOKE FIG. 7.1.2
ERT. BLANKING PULSES
SHUTTER OPEN/NORMAL
VIDEO GATE
SHUTTER 150MS PULSE
STAR MODE BLANKING FIG. 7.1.3.
VIDICON BLANKING
MER MODE VERT DEFLECTION CURRENT
MER MODE HORIZ DEFLECTION CURRENT
MER MODE KEYED CLAMP DRIVE
MER MODE SYSTEM SYNC/BLANKING PULSES
START FRAME
+29 V REG NONESS
VIDEO LOGIC FIG. 7.1.3
VIDEO Q1
+29 V FILTERED
VIDICON THERMAL CONTROL CIRCUIT FIG. 7.1.1
+25
+25
SURVLY CAMERA VIDICON TEMP (CONTROL ON/OFF)
VIDICON HEATER POWER
THERMAL CONTROL Q2
FRAME ID ENABLE SIGNAL & SHUTTER RESET
LECTRONICS TEMP
VIDICON FACEPLATE TEMP
KEYED CLAMP DRIVE
SYSTEM SYNC/BLANKING PULSES
VERTICAL DEFLECTION YOKE FIG. 7.2.2
VERT. DEFLECTION CURRENT
VIDICON TUBE FIG. 7.2.2
HORIZ AND VERT. BLANKING PULSES
VIDICON TUBE OUTPUT
HORIZONTAL DEFLECTION YOKE FIG. 7.2.2
HORIZ DEFLECTION CURRENT
+25 V REG
FRAME ID ENABLE SIGNAL AND SHUTTER RESET
SHUTTER TRIGGER
VIDEO Q1
VIDEO Q1
THERMAL CONTROL Q2
VIDICON TEMP CONTROL ON
FRAME ID ENABLE SIGNAL AND
ALL TEMP CONTROL OFF
SHUTTER TRIGGER
VIDICON HEATER POWER
VIDICON THERMAL CONTROL CIRCUIT FIG. 7.2.1


4
5
XMTR A A
VIDEO A
VIDEO B
VIDEO GATE
VIDEO GATE
SHUTTER TRIGGER INHIBIT
SHUTTER SOLENOIDS AND BLADES FIG. 7.1.3
+29 V SWITCHED
SOLENOID INPUT
SHUTTER 150MS PULSE
SHUTTER CONTROL FIG. 7.1.3
+22 V SWITCHED
SHUTTER OPEN/NORMAL
FRAME ID E
SHUTTER MODE OPEN O
UTPUT
+22 V SWITCHED
MIRROR CONTROL FIG. 7.1.4
MOTOR INPUT
DRIVE MOTOR AND MIRROR FIG. 7.1.4
MIRROR AZ
MIRROR EL
MIRROR STEPPING SIGNALS
VIDEO PROCESSING FIG. 7.1.2
+22 V SWITCHED
+29 V FILTERED
STEP FOCUS IN/OUT
STEP FILTER POSITION LEFT/RIGHT
SET FOCAL LENGTH
FILTER, FOCUS AND FOCAL LENGTH CONTROL FIG. 7.1.4
MOTOR INPUT
DRIVE MOTORS AND MECHANICS FIG. 7.1.4
MULT STEP F
LENS LOCAL
FILTER WHEE
LENS FOCUS
(CAMERA O
SHUTTER INHIBIT OVERRIDE
NORM.
+22 V SWITCHED
STEP IRIS OPEN/CLOSE
EMER
IRIS CONTROL FIG. 7.1.4
MOTOR INPUT
IRIS DRIVE MOTOR AND MECHANICS FIG. 7.1.4
LENS IRIS SE
LENS IRIS SE
IRIS SERVO ON
+25 V COMMON
START FRAME
+29 V FILTERED
CAMERA ELECTRONICS TEMP
VIDICON FACEPLATE TEMP
VIDEO A
VIDEO PROCESSING FIG. 7.2.2
VIDEO GATE
VIDEO B
SHUTTER RESET
SHUTTER CONTROL FIG. 7.2.3
SOLENOID INPUT
SHUTTER SOLENOIDS AND BLADES FIG. 7.2.3
APPR
APPR C
+22 V SWITCHED
+22 V SWITCHED
APPR CAMERA VIDICON THERMAL CO
APPR CAMERA VIDICON FACEPLATE T

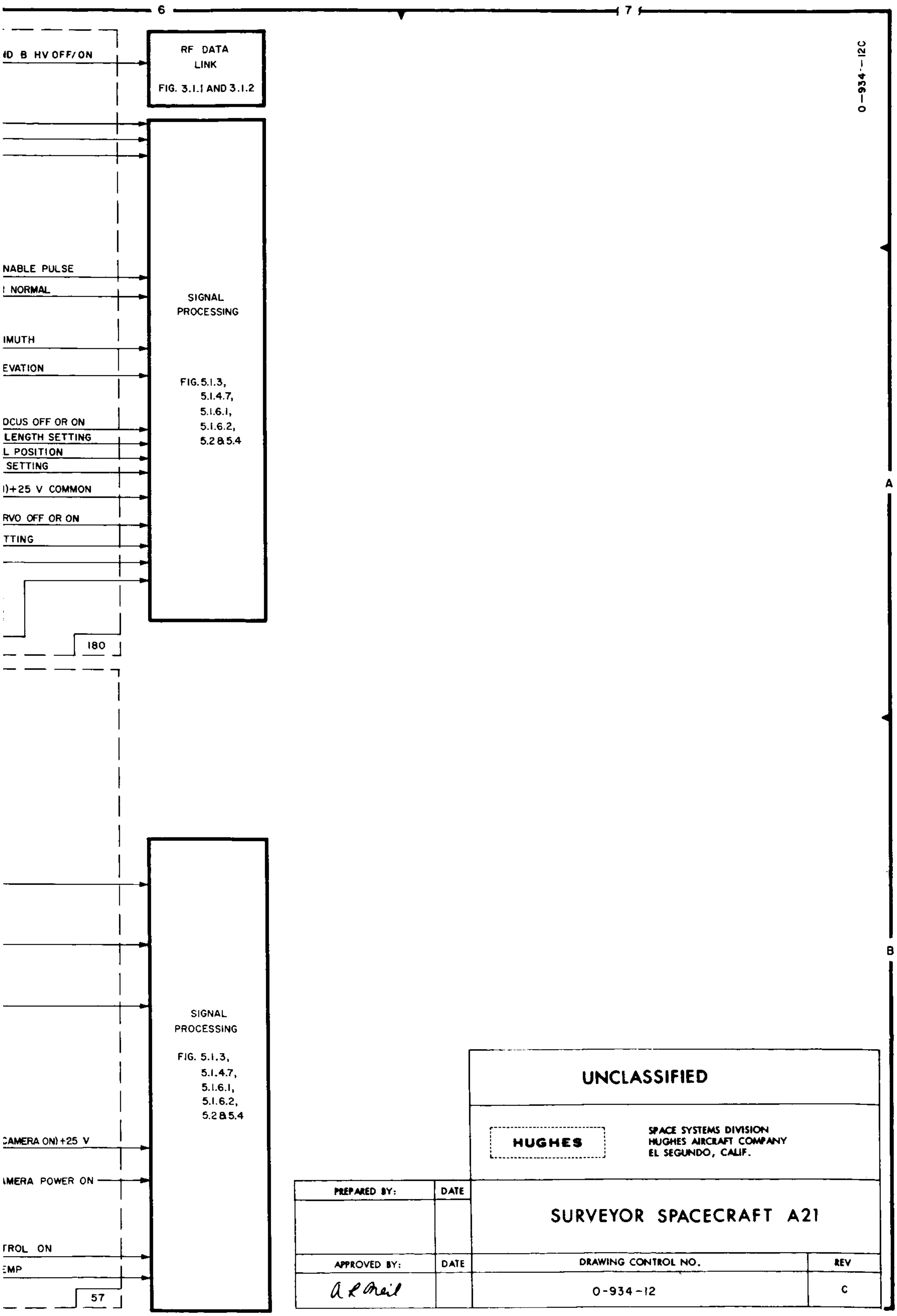


Figure 7.0. TV Cameras, Functional Block Diagram

SECTION VIII

MECHANICAL AND THERMAL SERVICES

This section contains functional block diagrams and general functional theory for the MECHANICAL AND THERMAL SERVICES FUNCTION. Functional schematic diagrams and functional theory for the MECHANICAL AND THERMAL SERVICES FUNCTION are included in Section VIII of Volume II.

8. 1 MECHANICAL AND THERMAL SERVICES FUNCTION. (Fig. 8. 0)

Prepared by Harry K. Sindo date 11 April 1966

Approved by ______________ date ______________

8. 2 GENERAL

The MECHANICAL AND THERMAL SERVICES FUNCTION consists of pyrotechnic devices, mechanical devices, and electronic and thermal control circuits. Its purpose is to actuate and/or release mechanical devices, turn the RADVS on and off, position the Planar Array Antenna and Solar Panel, and provide thermal control for spacecraft control items.

8. 3 OPERATIONAL REQUIREMENTS

The MECHANICAL AND THERMAL SERVICES FUNCTION requires +22 v and +29 v power from the POWER MANAGEMENT FUNCTION and +4. 85 v from the SIGNAL PROCESSING FUNCTION. Commands from ground control provide power switching and activation of the individual circuits.

8. 4 OPERATIONAL THEORY

8. 5 Squib Circuits

Commands from the SURVEYOR/CENTAUR INTERFACE, FLIGHT CONTROL, and COMMAND DECODING FUNCTIONS activate electronic circuits causing squibs to fire. Upon firing, the squibs actuate and/or release mechanical devices. The functions performed by squib firing are: unlock the Planar Array Antenna and Solar Panel, pressurize the vernier propulsion helium system, dump helium, extend the Landing Gear and Omni Antennas, lock the Landing Gear, ignite the Retro Rocket Engine, release the Retro Rocket Engine, and unlock Vernier Engine No. 1.

8. 6 RADVS Power Control Circuits

Commands from the FLIGHT CONTROL and COMMAND DECODING FUNCTIONS activate PYROTECHNIC SWITCHES. By switching power, the PYROTECHNIC SWITCHES provide turn-on and turn-off signals for the RADVS. Telemetry data indicates the state of the RADVS.

8. 7 Antenna and Solar Panel Positioner Circuits

During transit and after touchdown, the Planar Array Antenna and Solar Panel are unlocked by SQUIB firing. The Planar Array Antenna and Solar Panel are then positioned by the action of the Antenna and Solar Panel Positioner drive motors. The transit positioning of the Solar Panel may be accomplished automatically by a programmed sequence initiated by the "Centaur Separation Signal" or manually by a series of commands from ground control. All positioning on the lunar surface is accomplished by commands from ground control. Position indicating devices provide telemetry data for ground control.

8.8 Thermal Control Circuits

The thermal control circuits consist of HEATERS and HEATER SWITCHES that provide thermal control. Heater on-off commands are supplied by the COMMAND DECODING FUNCTION. Units that require thermal control are the Approach and Survey Television Cameras, AMR, Compartments A and B, Vernier Engine No. 1 fuel and oxidizer lines, Vernier Engine No. 2 Fuel and Oxidizer Tanks and lines, and Vernier Engine No. 3 Oxidizer Tank and fuel and oxidizer lines.

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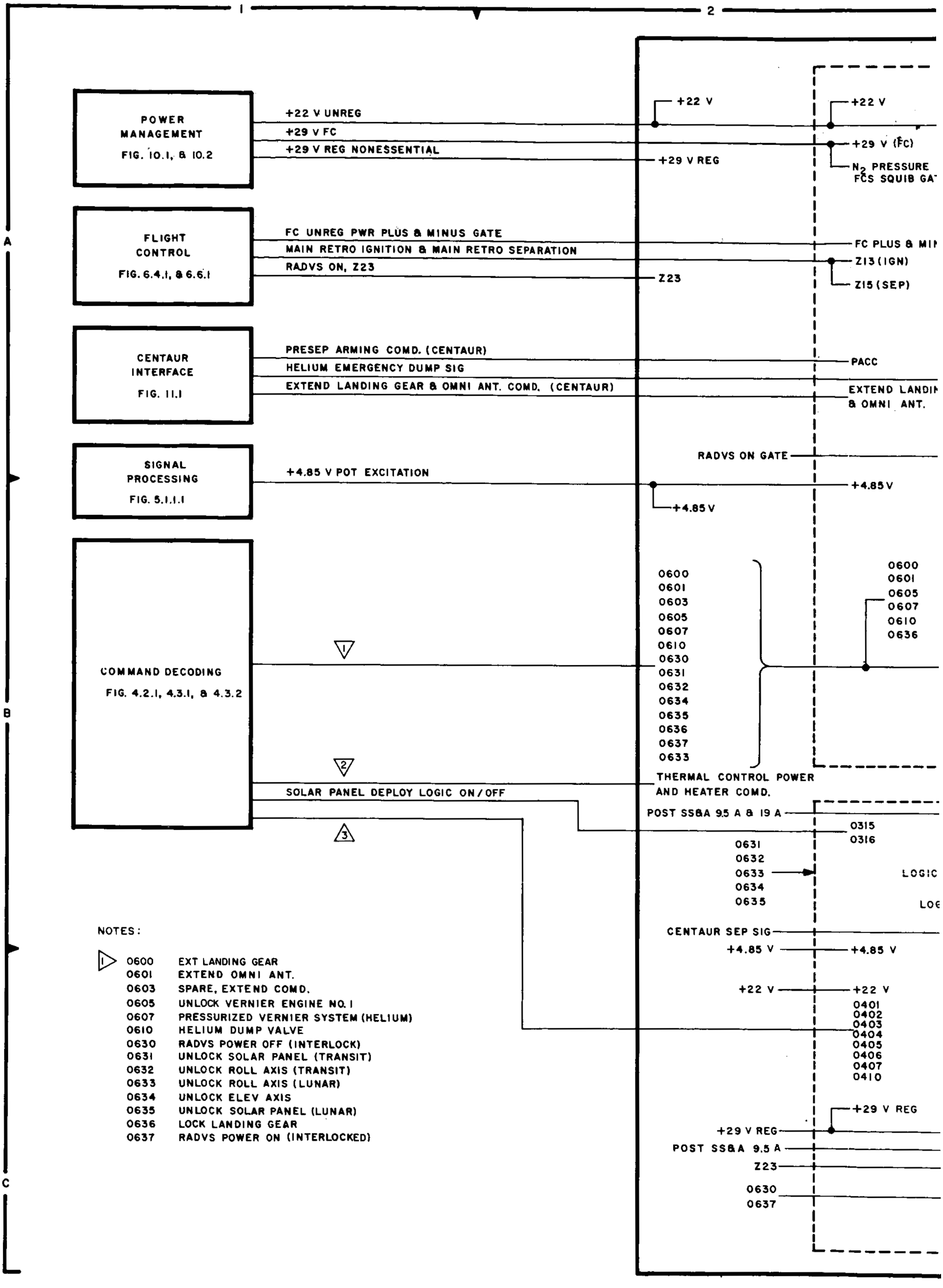
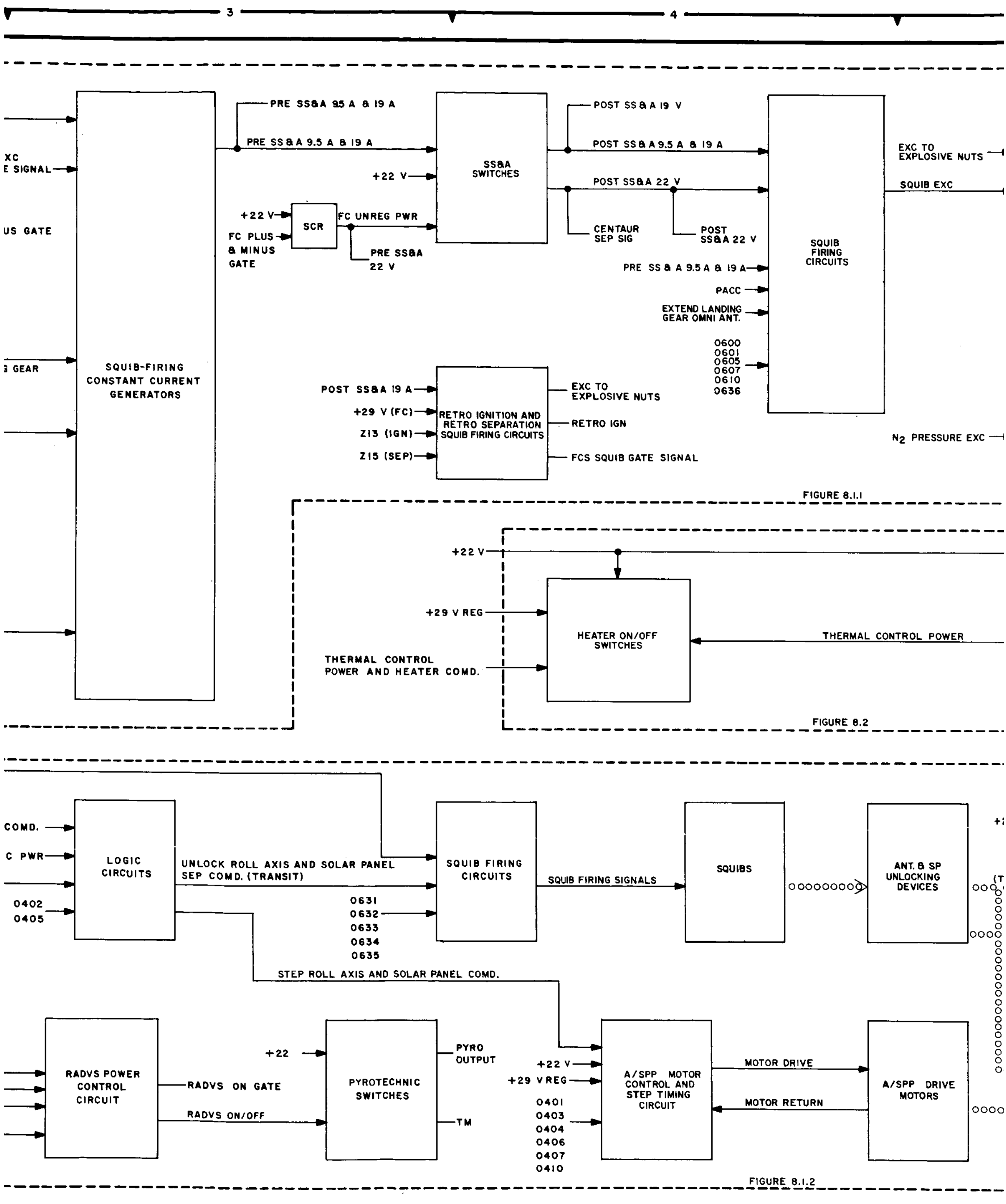


NOTES:

1	0600	EXT LANDING GEAR
	0601	EXTEND OMNI ANT.
	0603	SPARE, EXTEND COMD.
	0605	UNLOCK VERNIER ENGINE NO. 1
	0607	PRESSURIZED VERNIER SYSTEM (HELIUM)
	0610	HELIUM DUMP VALVE
	0630	RADVS POWER OFF (INTERLOCK)
	0631	UNLOCK SOLAR PANEL (TRANSIT)
	0632	UNLOCK ROLL AXIS (TRANSIT)
	0633	UNLOCK ROLL AXIS (LUNAR)
	0634	UNLOCK ELEV AXIS
	0635	UNLOCK SOLAR PANEL (LUNAR)
	0636	LOCK LANDING GEAR
	0637	RADVS POWER ON (INTERLOCKED)



3
4
PRE SS&A 9.5 A & 19 A
PRE SS&A 9.5 A & 19 A
SS&A SWITCHES
+22 V
+22 V
SCR
FC PLUS & MINUS GATE
FC UNREG PWR
PRE SS&A 22 V
POST SS & A 19 V
POST SS & A 9.5 A & 19 A
POST SS&A 22 V
CENTAUR SEP SIG
POST SS&A 22 V
PRE SS & A 9.5 A & 19 A
PACC
EXTEND LANDING GEAR OMNI ANT.
0600
0601
0605
0607
0610
0636
SQUIB FIRING CIRCUITS
EXC TO EXPLOSIVE NUTS
SQUIB EXC
XC
E SIGNAL
US GATE
GEAR
SQUIB-FIRING CONSTANT CURRENT GENERATORS
POST SS&A 19 A
+29 V (FC)
Z13 (IGN)
Z15 (SEP)
RETRO IGNITION AND RETRO SEPARATION SQUIB FIRING CIRCUITS
EXC TO EXPLOSIVE NUTS
RETRO IGN
FCS SQUIB GATE SIGNAL
N2 PRESSURE EXC
FIGURE 8.1.1
+22 V
+29 V REG
THERMAL CONTROL POWER AND HEATER COMD.
HEATER ON/OFF SWITCHES
THERMAL CONTROL POWER
FIGURE 8.2
COMD.
C PWR
0402
0405
LOGIC CIRCUITS
UNLOCK ROLL AXIS AND SOLAR PANEL SEP COMD. (TRANSIT)
0631
0632
0633
0634
0635
SQUIB FIRING CIRCUITS
SQUIB FIRING SIGNALS
SQUIBS
ANT. & SP UNLOCKING DEVICES
STEP ROLL AXIS AND SOLAR PANEL COMD.
RADVS POWER CONTROL CIRCUIT
RADVS ON GATE
RADVS ON/OFF
+22
PYROTECHNIC SWITCHES
PYRO OUTPUT
TM
+22 V
+29 V REG
0401
0403
0404
0406
0407
0410
A/SPP MOTOR CONTROL AND STEP TIMING CIRCUIT
MOTOR DRIVE
MOTOR RETURN
A/SPP DRIVE MOTORS
FIGURE 8.1.2

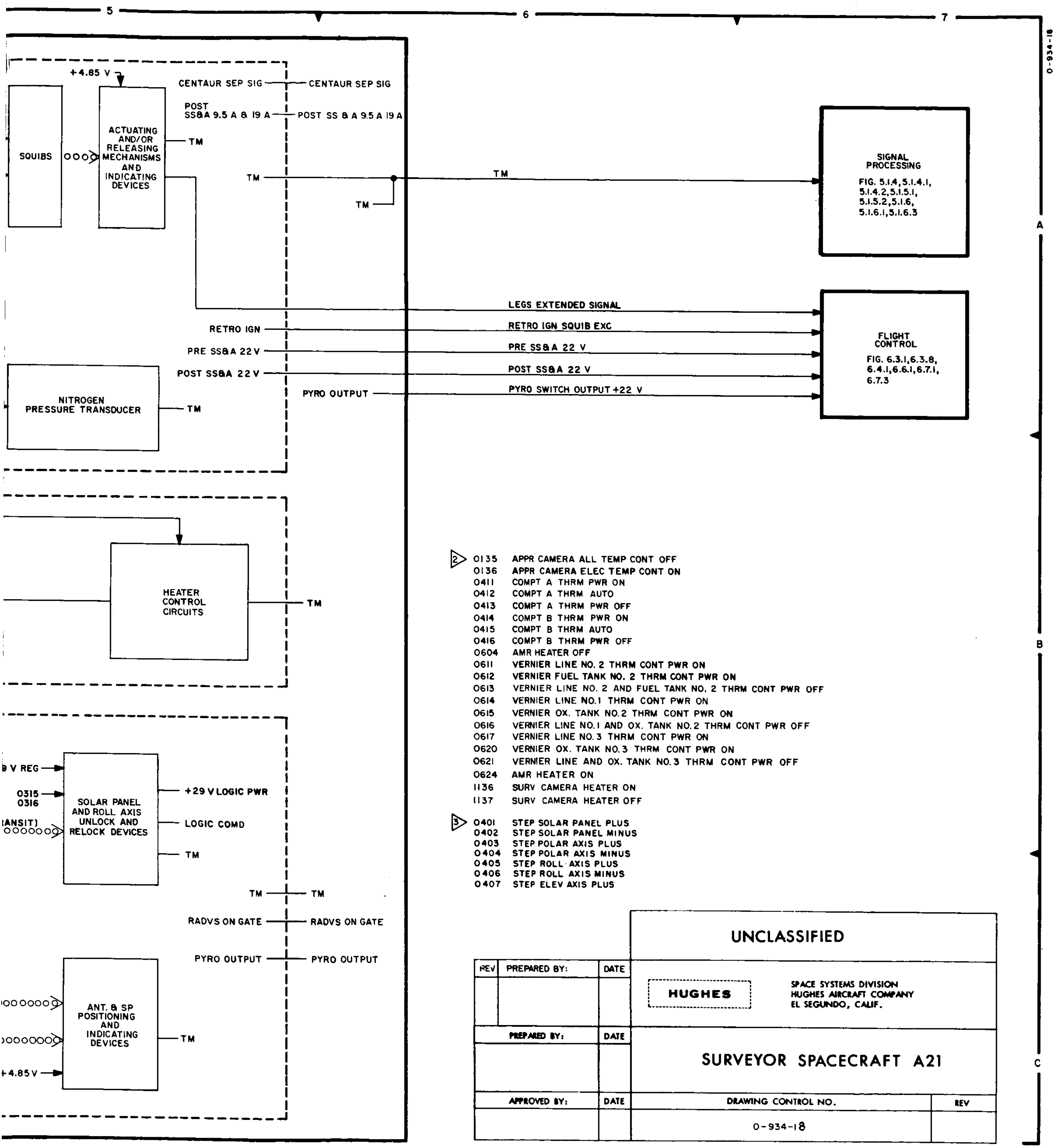


Figure 8.0. Mechanical and Thermal Services, Functional Block Diagram

SECTION IX

VEHICLE ENGINEERING INSTRUMENTATION

This section contains functional block diagrams and general functional theory for the VEHICLE ENGINEERING INSTRUMENTATION FUNCTION. Functional schematic diagrams and functional theory are included in Section IX of Volume II.

9.1 VEHICLE ENGINEERING INSTRUMENTATION FUNCTION. (Fig. 9.0)

Prepared by HB Rackwell date 4/12/66

Approved by ______________ date ____________

9.2 GENERAL

The VEHICLE ENGINEERING INSTRUMENTATION FUNCTION consists of thermal sensors, accelerometers, and strain gages. Its purpose is to provide engineering data related to spacecraft performance and response to the environment.

9.3 OPERATIONAL REQUIREMENTS

The VEHICLE ENGINEERING INSTRUMENTATION FUNCTION requires +29 v Nonessential power in order to become operational. This power is applied or removed by ground commands.

9.4 OPERATIONAL THEORY

9.5 Thermal Sensors.

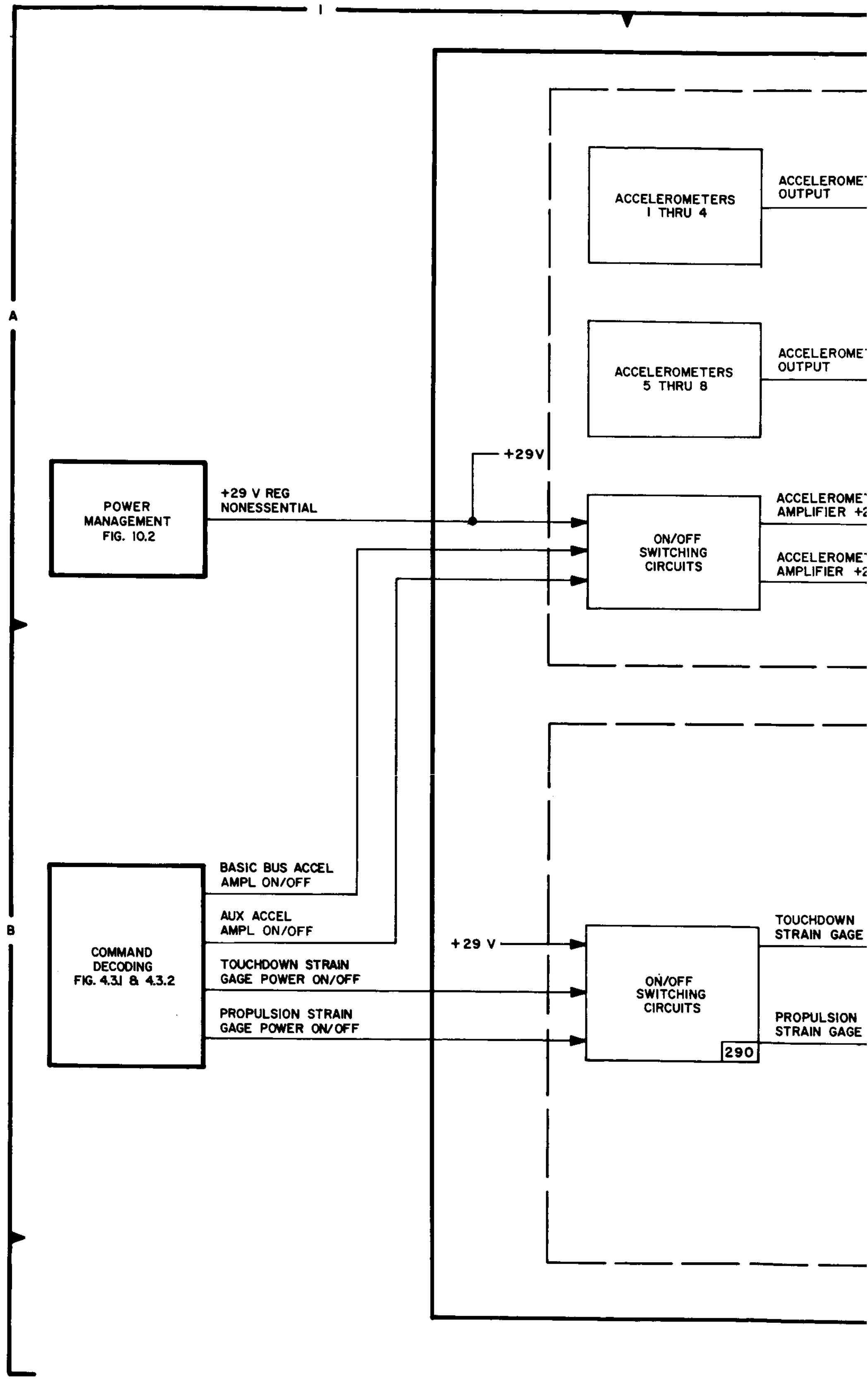
Temperature measurements are made during all phases of the flight mission by resistive-type thermal sensors that are located throughout the spacecraft. This data is subsequently transmitted to ground control.

9.6 Accelerometers.

A set of four accelerometers (1 thru 4) measure mechanical vibration during launch thru Centaur separation. When +29 v is applied to the ACCELEROMETER AMPLIFIER ASSEMBLY, accelerometer outputs are supplied to the CENTAUR INTERFACE FUNCTION for transmission to ground control. A second set of accelerometers, 5 thru 8, will not be used on the first flight.

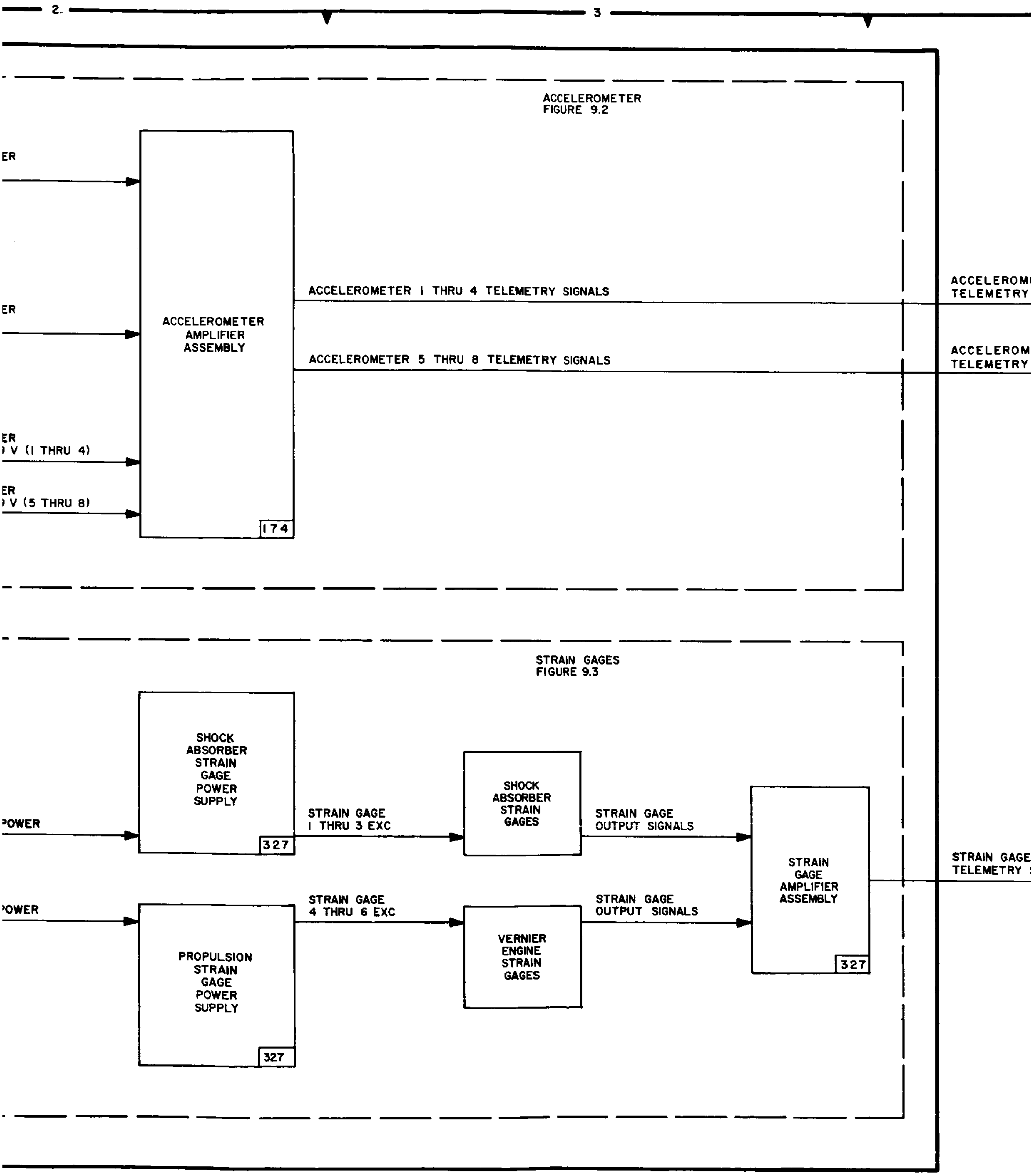
9.7 Strain Gages.

Six electro-mechanical strain gages provide data outputs to the SIGNAL PROCESSING FUNCTION during the midcourse correction and terminal descent. Two command-activated power supplies provide excitation voltages to the strain gages.



A
B
POWER MANAGEMENT FIG. 10.2
+29 V REG NONESSENTIAL
COMMAND DECODING FIG. 4.3.1 & 4.3.2
BASIC BUS ACCEL AMPL ON/OFF
AUX ACCEL AMPL ON/OFF
TOUCHDOWN STRAIN GAGE POWER ON/OFF
PROPULSION STRAIN GAGE POWER ON/OFF
+29V
+29 V
ACCELEROMETERS 1 THRU 4
ACCELEROMETERS 5 THRU 8
ON/OFF SWITCHING CIRCUITS
ON/OFF SWITCHING CIRCUITS
290
ACCELEROME OUTPUT
ACCELEROME OUTPUT
ACCELEROME AMPLIFIER +2
ACCELEROME AMPLIFIER +2
TOUCHDOWN STRAIN GAGE
PROPULSION STRAIN GAGE

9-3-1


2
3
ACCELEROMETER
FIGURE 9.2
ER
ER
ER
V (I THRU 4)
ER
V (5 THRU 8)
ACCELEROMETER AMPLIFIER ASSEMBLY
174
ACCELEROMETER I THRU 4 TELEMETRY SIGNALS
ACCELEROMETER 5 THRU 8 TELEMETRY SIGNALS
ACCELEROM
TELEMETRY
ACCELEROM
TELEMETRY
STRAIN GAGES
FIGURE 9.3
POWER
POWER
SHOCK ABSORBER STRAIN GAGE POWER SUPPLY
327
PROPULSION STRAIN GAGE POWER SUPPLY
327
STRAIN GAGE
I THRU 3 EXC
STRAIN GAGE
4 THRU 6 EXC
SHOCK ABSORBER STRAIN GAGES
VERNIER ENGINE STRAIN GAGES
STRAIN GAGE
OUTPUT SIGNALS
STRAIN GAGE
OUTPUT SIGNALS
STRAIN GAGE AMPLIFIER ASSEMBLY
327
STRAIN GAGE
TELEMETRY

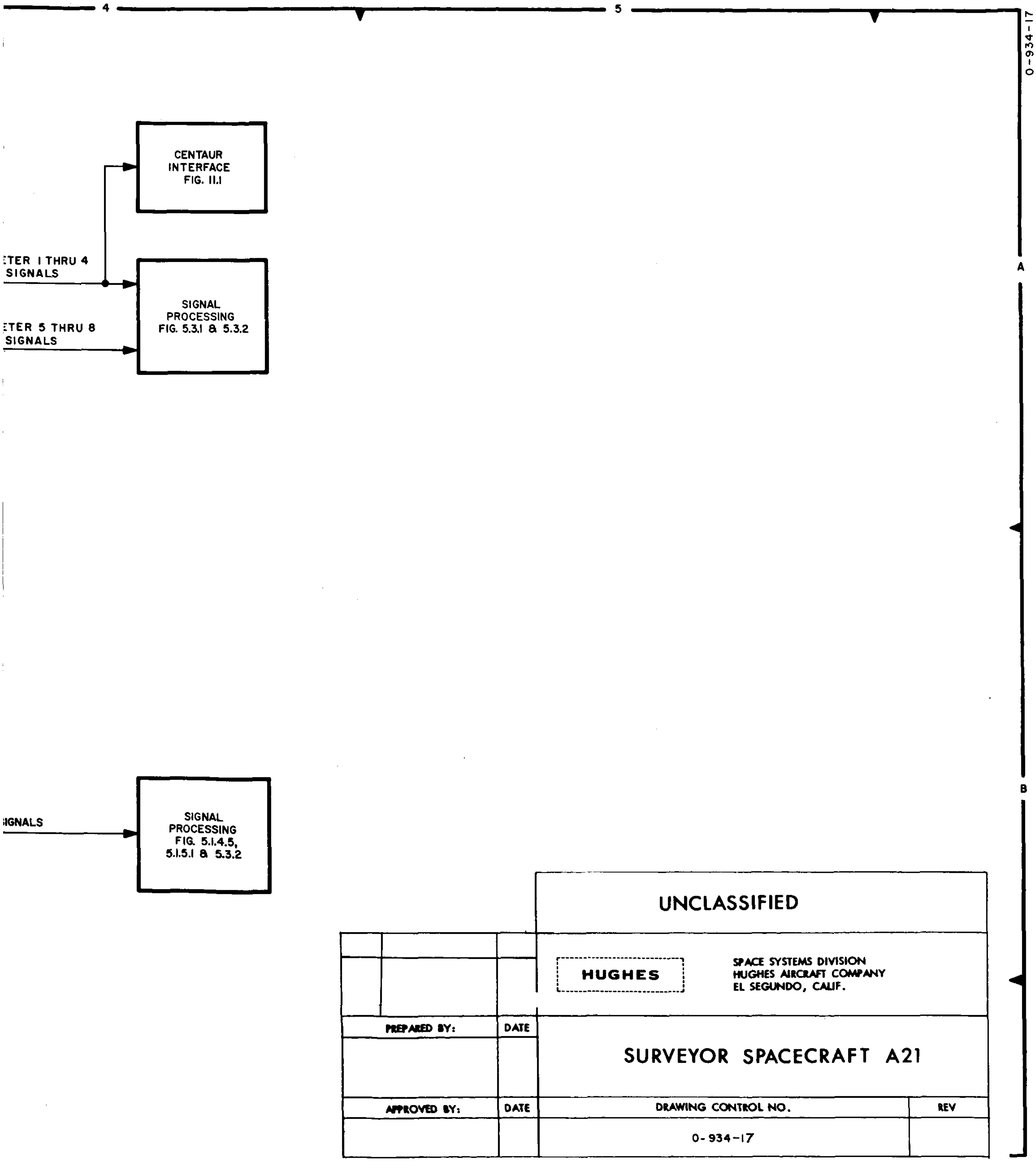


Figure 9.0. Vehicle Engineering, Functional Block Diagram

SECTION X

POWER MANAGEMENT

This section contains functional block diagrams and general functional theory for the POWER MANAGEMENT FUNCTION. Functional schematic diagrams and functional theory are included in Section X of Volume II.

10.1 POWER MANAGEMENT FUNCTION. (Fig. 10.0)

Prepared by E. J. Bennett date 17 Nov '64
Approved by E. Barna date 20 Nov '64

10.2 GENERAL.

The POWER MANAGEMENT FUNCTION consists of equipment contained within the Battery Charge Regulator (BCR), Solar Panel, Main Battery, Auxiliary Battery, Boost Regulator, and the Auxiliary Battery Control (ABC). The purpose of this function is to generate, store, convert, and control electrical power for equipment on board the spacecraft.

10.3 OPERATIONAL REQUIREMENTS.

The POWER MANAGEMENT FUNCTION is designed to operate automatically. However, control may be exerted by means of ground commands. These commands, from the COMMAND DECODING FUNCTION, are the only external inputs from the spacecraft. They are:

a. OCR and OCR bypass on/off control - to turn the OCR on and off and bypass OCR switching in the event of OCR failure or for increased efficiency when Solar Panel voltage is low.

b. Battery pressure logic enable/disable - to override automatic battery charging.

c. ABC mode commands - to control the application of the batteries to the unregulated bus.

d. Trip circuit bypass/enable - allows bypassing of BR Overload/ Undervoltage Trip Circuit in event of failure and on/off control.

e. Boost Regulator ECU control - allows nonessential and flight control loads to be turned off.

10.4 OPERATIONAL THEORY.

The prime source of electrical power for the spacecraft is the Solar Panel. It provides power when its photoconductive cells are oriented so as to absorb solar energy. The Solar Panel produces a minimum of 57 watts at a maximum expected temperature of 115°C. The Solar Panel output voltage is applied to the input of the Optimum Charge Regulator (OCR) within the BCR.

The OCR transfers Solar Panel output at optimum power to the unregulated power bus. It operates automatically when Solar Panel output reaches a nominal value.

The Battery Charge Logic within the BCR provides controlled charging of the Main Battery. Automatic charging ceases when battery manifold pressure rises to 65 psi and is restored when the pressure drops to 60 psi. The Battery Charge Logic reduces OCR output to trickle charging of the battery when battery voltage reaches a nominal 27.3 volts and terminates charging at 27.5 volts.

The Auxiliary Battery Control provides for automatic application of the Main Battery and Auxiliary Battery voltages to the unregulated power bus. When the Main Battery voltage drops below preset levels such as during peak load periods, the ABC automatically applies the Auxiliary Battery to the unregulated bus.

The Main Battery provides power to the unregulated bus to augment or replace the Solar Panel output. It is charged by power from the Solar Panel in excess of the needs of the spacecraft. During lunar night, the Main Battery supplies all spacecraft power.

The Auxiliary Battery provides a backup for the Solar Panel and Main Battery. It provides the additional peak load and power storage capability required for transit and landing during initial spacecraft flights. The Auxiliary Battery is not normally placed under charge.

The Boost Regulator converts unregulated bus voltage into regulated 29 v and applies it to the essential, nonessential, and flight control buses. The Boost Regulator ECU may be controlled by earth command. Conversion continues until the earth command, 29 v regulated nonessential, and 29 v flight control are removed.

The Overload/Undervoltage Trip Circuit within the BR provides protection for the nonessential loads and the BR during nonessential bus overload, low unregulated input voltage, or low nonessential bus voltage conditions.

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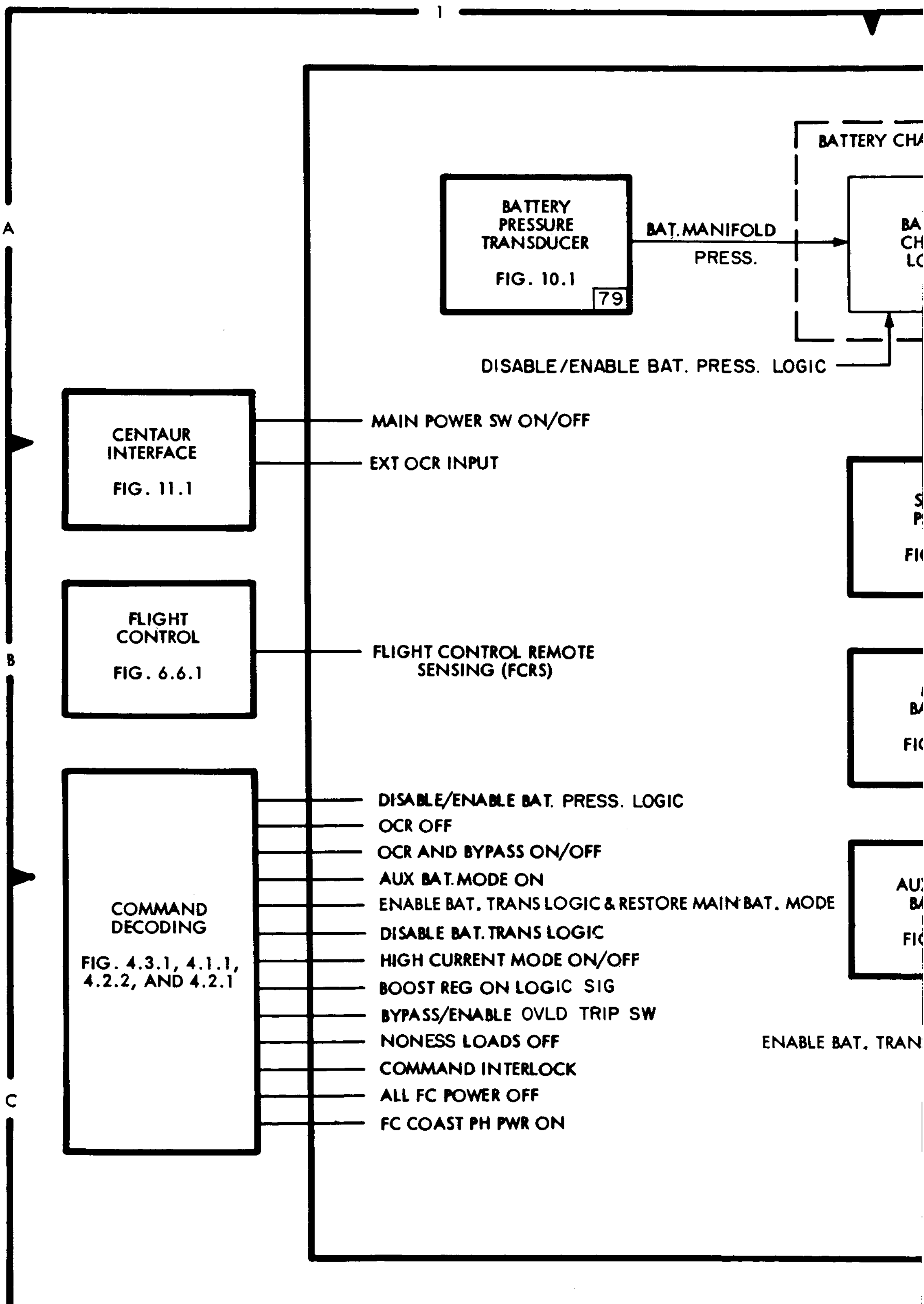
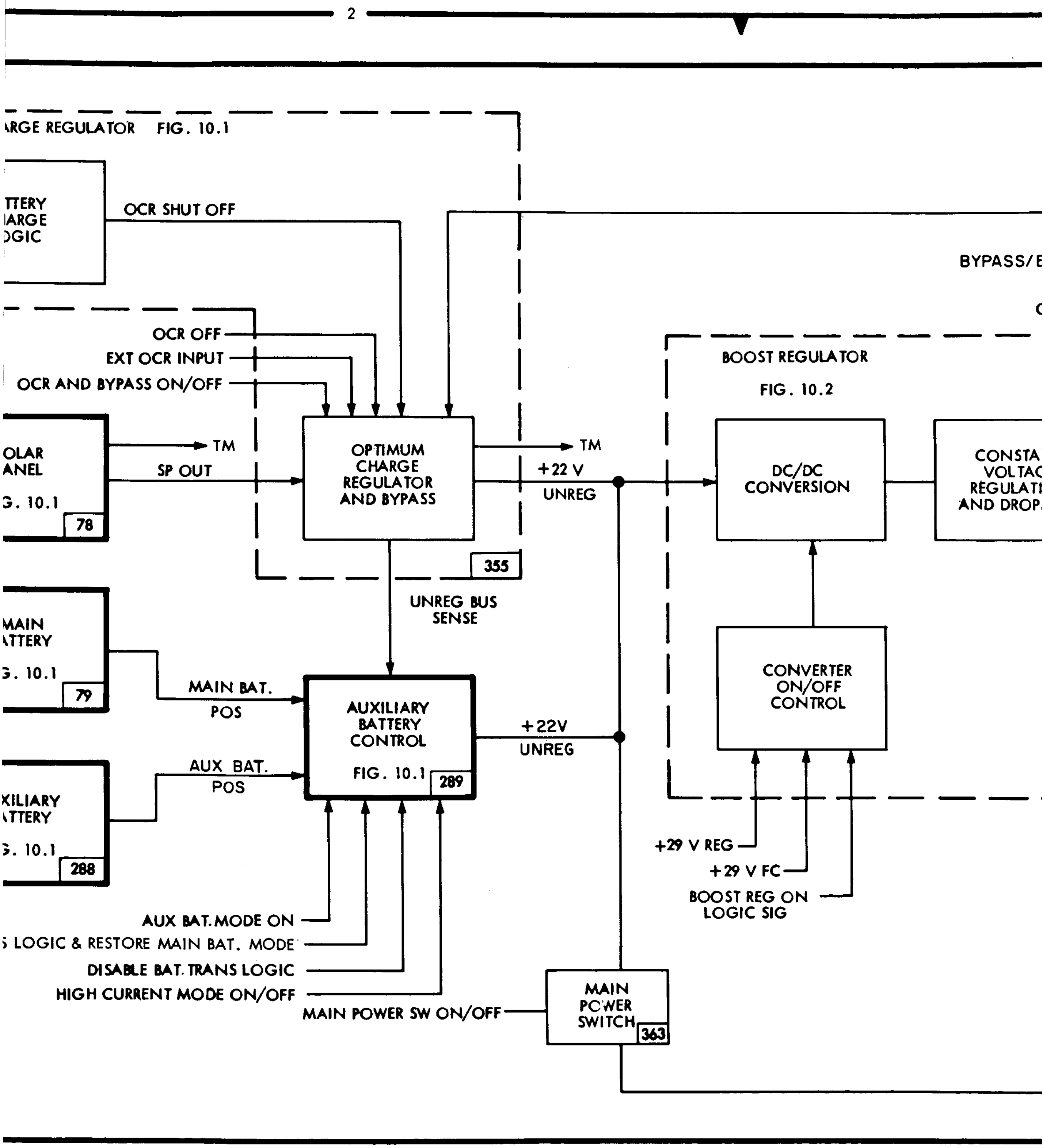
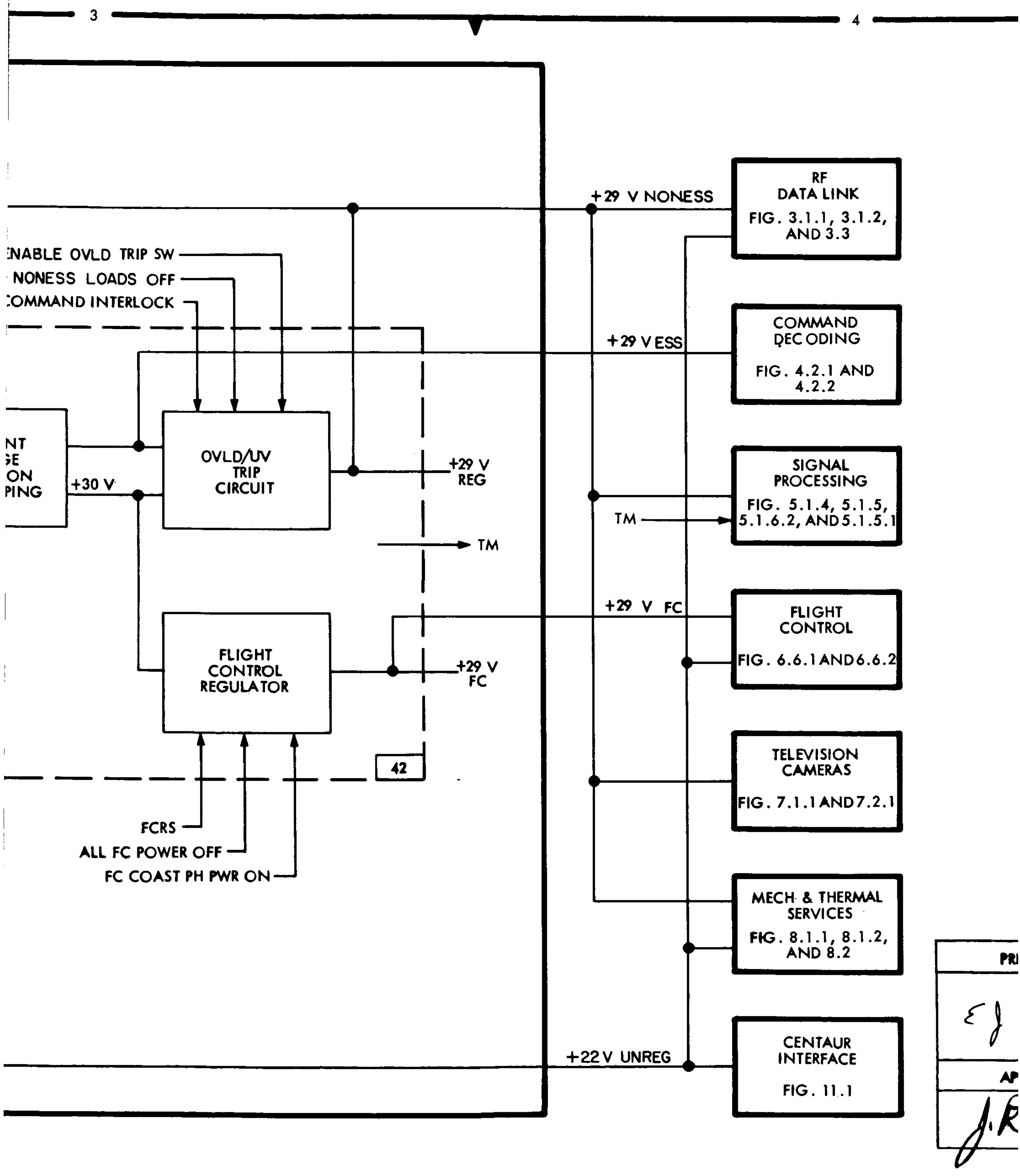


1
A
B
C
BATTERY CHA
BATTERY PRESSURE TRANSDUCER
FIG. 10.1
79
BAT. MANIFOLD PRESS.
BA CH LC
DISABLE/ENABLE BAT. PRESS. LOGIC
CENTAUR INTERFACE
FIG. 11.1
MAIN POWER SW ON/OFF
EXT OCR INPUT
FLIGHT CONTROL
FIG. 6.6.1
FLIGHT CONTROL REMOTE SENSING (FCRS)
COMMAND DECODING
FIG. 4.3.1, 4.1.1, 4.2.2, AND 4.2.1
DISABLE/ENABLE BAT. PRESS. LOGIC
OCR OFF
OCR AND BYPASS ON/OFF
AUX BAT. MODE ON
ENABLE BAT. TRANS LOGIC & RESTORE MAIN BAT. MODE
DISABLE BAT. TRANS LOGIC
HIGH CURRENT MODE ON/OFF
BOOST REG ON LOGIC SIG
BYPASS/ENABLE OVLD TRIP SW
NONESS LOADS OFF
COMMAND INTERLOCK
ALL FC POWER OFF
FC COAST PH PWR ON
ENABLE BAT. TRAN



2
RGE REGULATOR FIG. 10.1
TTERY
IARGE
OGIC
OCR SHUT OFF
BYPASS/E
OCR OFF
EXT OCR INPUT
OCR AND BYPASS ON/OFF
BOOST REGULATOR
FIG. 10.2
OLAR
ANEL
3. 10.1
78
TM
SP OUT
OPTIMUM
CHARGE
REGULATOR
AND BYPASS
TM
+22 V
UNREG
DC/DC
CONVERSION
CONSTA
VOLTAG
REGULATI
AND DROP
355
UNREG BUS
SENSE
MAIN
ATTERY
3. 10.1
79
MAIN BAT.
POS
AUXILIARY
BATTERY
CONTROL
FIG. 10.1
289
+22V
UNREG
CONVERTER
ON/OFF
CONTROL
XILIARY
ATTERY
3. 10.1
288
AUX BAT.
POS
+29 V REG
+29 V FC
BOOST REG ON
LOGIC SIG
AUX BAT. MODE ON
LOGIC & RESTORE MAIN BAT. MODE
DISABLE BAT. TRANS LOGIC
HIGH CURRENT MODE ON/OFF
MAIN POWER SW ON/OFF
MAIN
POWER
SWITCH
363



3
4
:NABLE OVLD TRIP SW
NONESS LOADS OFF
:OMMAND INTERLOCK
NT
;E
ON
PING
+30 V
OVLD/UV
TRIP
CIRCUIT
+29 V
REG
TM
FLIGHT
CONTROL
REGULATOR
+29 V
FC
42
FCRS
ALL FC POWER OFF
FC COAST PH PWR ON
+29 V NONESS
+29 V ESS
TM
+29 V FC
+22 V UNREG
RF
DATA LINK
FIG. 3.1.1, 3.1.2, AND 3.3
COMMAND
DECODING
FIG. 4.2.1 AND 4.2.2
SIGNAL
PROCESSING
FIG. 5.1.4, 5.1.5, 5.1.6.2, AND 5.1.5.1
FLIGHT
CONTROL
FIG. 6.6.1 AND 6.6.2
TELEVISION
CAMERAS
FIG. 7.1.1 AND 7.2.1
MECH & THERMAL
SERVICES
FIG. 8.1.1, 8.1.2, AND 8.2
CENTAUR
INTERFACE
FIG. 11.1
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HUGHES	SPACE SYSTEMS DIVISION HUGHES AIRCRAFT COMPANY EL SEGUNDO, CALIF.		

PARED BY:	DATE	SURVEYOR SPACECRAFT A21	
Bennett	11/11/64		
ROVED BY:	DATE	DRAWING CONTROL NO.	REV
Stover	11/11/64	0-934-11	D

Figure 10.0. Power Management, Functional Block Diagram

SECTION XI

SURVEYOR/CENTAUR INTERFACE

This section contains functional block diagrams and general functional theory for the SURVEYOR/CENTAUR INTERFACE FUNCTION. Functional schematic diagrams and functional theory are included in Section XI of Volume II.

11.1 SURVEYOR/CENTAUR INTERFACE FUNCTION.

Prepared by DB Rockwell date 4/12/66

Approved by ________________ date ____________

11.2 GENERAL.

The purpose of the SURVEYOR/CENTAUR INTERFACE FUNCTION is to provide the interconnection between the Surveyor spacecraft and the Centaur in order to satisfy prelaunch and launch thru Centaur separation control, telemetry, and command requirements.

11.3 OPERATIONAL REQUIREMENTS.

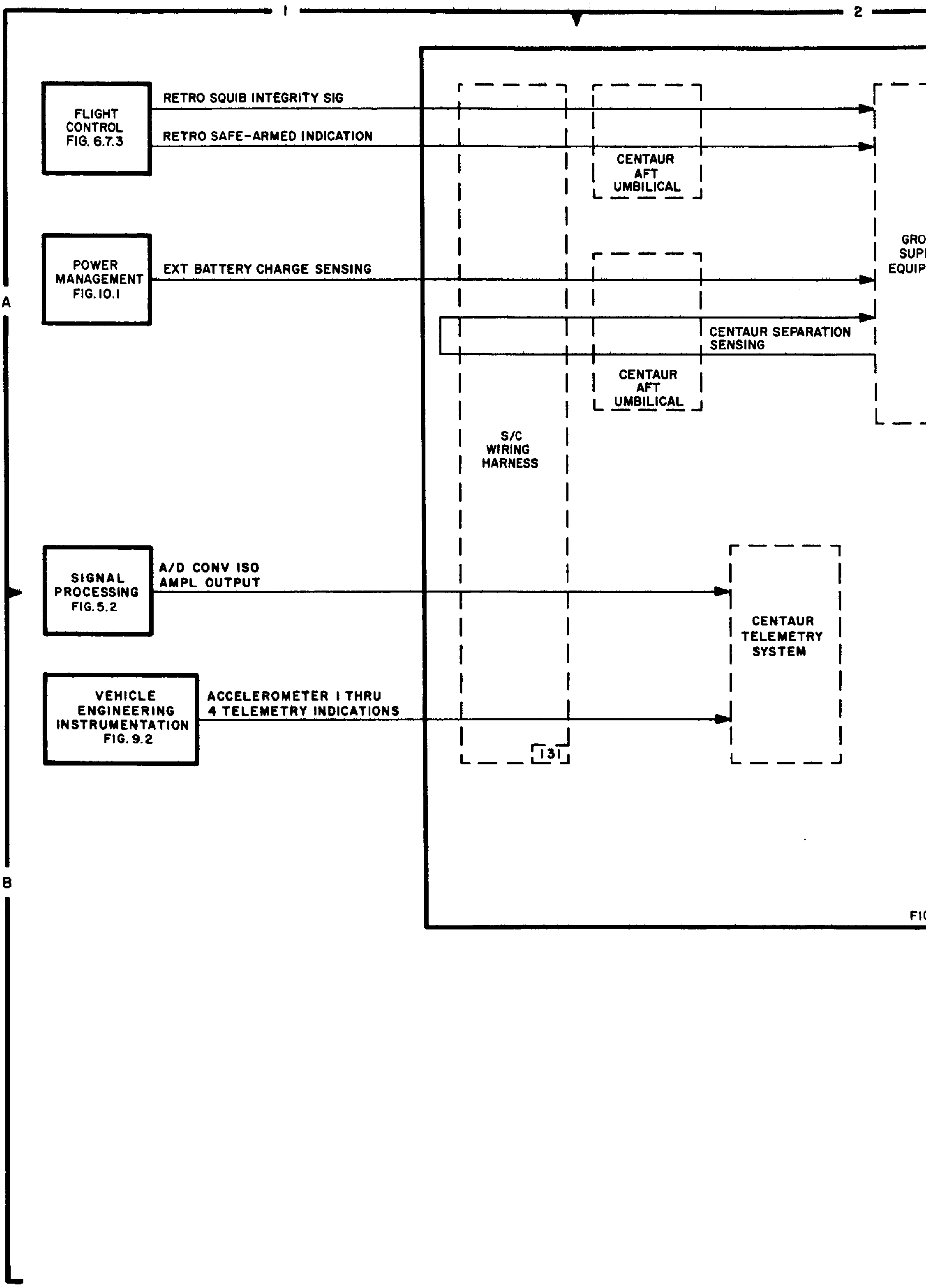
The SURVEYOR/CENTAUR INTERFACE FUNCTION requires that electrical continuity be maintained between the spacecraft and the Centaur during the period prelaunch thru separation.

11.4 OPERATIONAL THEORY.

During the prelaunch period, the GROUND SUPPORT EQUIPMENT provides certain spacecraft requirements through the spacecraft/Centaur electrical connectors. These requirements include supplying electrical power, control signals, monitoring of Retro Rocket Engine squib integrity and the charge on the spacecraft battery, and provision for remotely arming the Retro Rocket Engine ignitor.

During the period launch thru separation, data related to spacecraft performance is telemetered to ground control through the CENTAUR TELEMETRY SYSTEM.

Shortly before separation, the CENTAUR FLIGHT CONTROL PROGRAMMER provides a sequence of command signals to the spacecraft. These preseparation commands extend the landing gear, unlock the Omnidirectional/Antenna, and turn on the transmitter in high power.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FLIGHT CONTROL FIG. 6.7.3
RETRO SQUIB INTEGRITY SIG
RETRO SAFE-ARMED INDICATION
CENTAUR AFT UMBILICAL
POWER MANAGEMENT FIG. 10.1
EXT BATTERY CHARGE SENSING
GRO SUP EQUIP
CENTAUR SEPARATION SENSING
CENTAUR AFT UMBILICAL
S/C WIRING HARNESS
SIGNAL PROCESSING FIG. 5.2
A/D CONV ISO AMPL OUTPUT
CENTAUR TELEMETRY SYSTEM
VEHICLE ENGINEERING INSTRUMENTATION FIG. 9.2
ACCELEROMETER 1 THRU 4 TELEMETRY INDICATIONS
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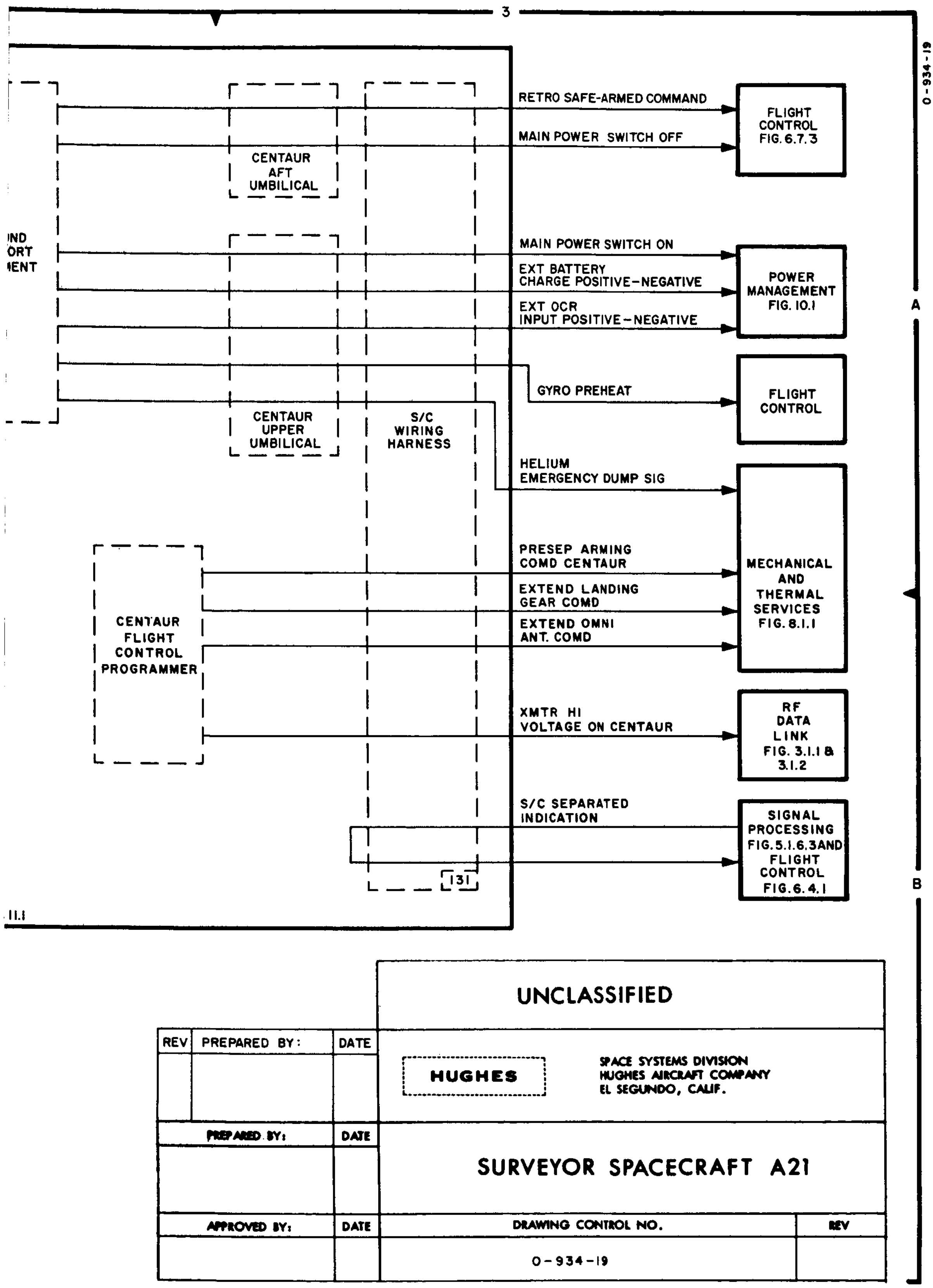

igure 11.0. Surveyor/Centaur Interface, Functional Block Diagram